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BOONTON

BOONTON ELECTRONICS CORPORATION

42BD/42CD

CALIBRATION PROCEDURE

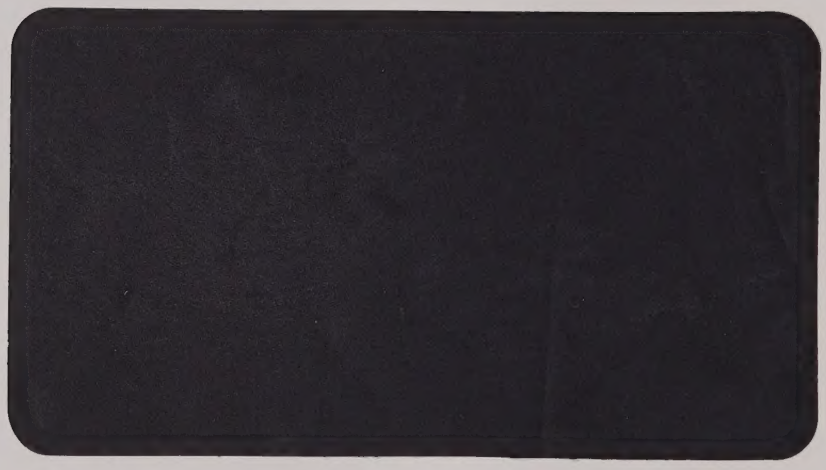
FOR

RF MICROWATTMETER

42B

WITH

MP MASTER
MA24649



JUL 19 1996

TECHNICAL MANUAL

CALIBRATION PROCEDURE

FOR

RF MICROWATTMETER

42B

WITH

POWER DETECTORS

41 - 4A, 41 - 4B, & 41 - 4E

(BOONTON)

This publication replaces T.O. 33K4-4-202-1 dated 30 April 1995.

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30 APRIL 1996

RF MICROWATTMETER

42B

WITH

POWER DETECTORS

41 - 4A, 41 - 4B, & 41 - 4E

(BOONTON)

1 CALIBRATION DESCRIPTION:

Table 1.

Test Instrument (TI) Characteristics		Performance Specifications	Test Method
Frequency		Range: 0.2 MHz to 18 GHz (41-4E) 0.2 MHz to 12.4 GHz (41-4B) 0.2 MHz to 7.0 GHz (41-4A) Accuracy: N/A	Not Calibrated
Power		Range: 1 nW to 10 mW -50 to +10 dBm Accuracy: <10 nW (-50 dBm) ±1% FSI ±0.15 dB; >10 nW (+10 to -40 dB) ±0.5% FSI ±0.15 dB; Plus Detector Error	Compared to a Standard Power Measuring System
Power Detector Error		Range: 1 nW to 10 mW Accuracy:	Compared to a Standard Power Measuring System
	41-4A	±0.3 dB, 0.2 to 100 MHz; ±0.2 dB, 100 MHz to 4 GHz; ±0.3 dB, 4 to 7 GHz	
	41-4B	±0.3 dB, 0.2 to 100 MHz; ±0.2 dB, 100 MHz to 4 GHz; ±0.3 dB, 4 to 8 GHz; ±0.4 dB, 8 to 12.4 GHz	
	41-4E	±0.3 dB, 0.2 to 100 MHz; ±0.2 dB, 100 MHz to 4 GHz; ±0.4 dB, 4 to 12.4 GHz; ±0.6 dB, 12.4 to 18 GHz	

Table 1 (Cont.)

Test Instrument Characteristics	(TI)	Performance Specifications	Test Method
	41-4A 41-4B 41-4E	Range: 10 nW to 10 mW Error: ±0.2 dB (200 kHz to 4 GHz) ±0.3 dB (4 to 8.2 GHz) ±0.4 dB (8.2 to 12.4 GHz) ±0.6 dB (12.4 to 18 GHz)	

2 EQUIPMENT REQUIREMENTS:

	Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.1	STANDARD DC VOLTAGE	Range: 0 to 3 VDC Accuracy: ±0.2%	Fluke 332B	
2.2	DIGITAL VOLTMETER	Range: 0 to 1 Volt Accuracy: ±0.1%	Fluke 8300A	
2.3	THERMAL CONVERTER	Range: 1 Volt Accuracy: ±0.08%	Hewlett-Packard 11050A	
2.4	SIGNAL GENERATOR	Range: 200 kHz Accuracy: ±1%	Hewlett-Packard 606A	
2.5	ATTENUATOR STEP	Range: 0 to 50 dB Accuracy: ±0.1 dB	Weinschel 64A	
2.6	RF SWEEPER/ SYNCHRONIZING COUNTER	Range: 0 to 10 mW 10 MHz to 18 GHz Accuracy: Power N/A Frequency ±0.02%	EIP 931-9320/575-04	
2.7	SIGNAL GENERATORS	Range: 100 MHz to 12.4 GHz Accuracy: ±1%	Hewlett-Packard 608C, 612A, 616B, 618C, 620A, 626A	
2.8	RF SOURCES	Range: 3.95 to 18 GHz Accuracy: ±1%	Hewlett-Packard E10-693C, E10-694C, E10-695C	

	Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.9	POWER MEASUREMENT CALIBRATION	Range: 5 to 10 mW DC Sub power @ 10 MHz Accuracy: RF CONTROL UNIT: ±(0.01% + 5 µW) STANDARD MOUNT: Cal factors charted by AGMC on AFLC Form 5564	Weinschel PMCS-1B	Weinschel PMCS-1A SYSTEM

3 PRELIMINARY OPERATIONS:

3.1 Review and become familiar with the entire procedure before beginning calibration process.

WARNING

Unless otherwise designated, and prior to beginning the Calibration Process, ensure that all test equipment voltage and/or current outputs are set to zero (0) or turned off, where applicable. Ensure that all equipment switches are set to the proper position before making connections or applying power.

3.2 Each Detector is calibrated with a particular 42B Power Meter. Label each separate Detector "use with 42B Power Meter serial #____ only". In the case of systems label the Meter with a Limited Certification Label reading "Use only the Detector calibrated with this unit. See label on Detector".

3.3 Set TI rear panel POWER switch to 115 Volts.

3.4 Connect TI to a 115 Volt 60 Hz power source. Set POWER switch to ON and allow a 5 minute warm-up.

3.5 Depress TI -50 dBm FULL SCALE switch.

3.6 Adjust TI ZERO control until meter pointer rest at the RED/BLACK ZERO reference mark at left end of scale.

NOTE

Because of the instrument's sensitivity on the -50 dBm range, meter pointer fluctuations of up to ±0.5 dB may be expected; proper zero adjustment is achieved when the pointer fluctuates evenly around the ZERO reference mark.

3.7 Use only that portion of the calibration process which pertains to the TI under calibration.

4 CALIBRATION PROCESS:

NOTE

Unless otherwise specified, verify the results of each test and take corrective action whenever the test requirement is not met, before proceeding.

4.1 POWER CALIBRATION @ 200 kHz:

4.1.1 Set Signal Generator OUTPUT controls for minimum output, and FREQUENCY controls for 200 kHz.

4.1.2 Set TI FULL SCALE switches for 10 mW and CAL FACTOR control to 0 dBm.

4.1.3 Connect equipment as shown in Figure 1.

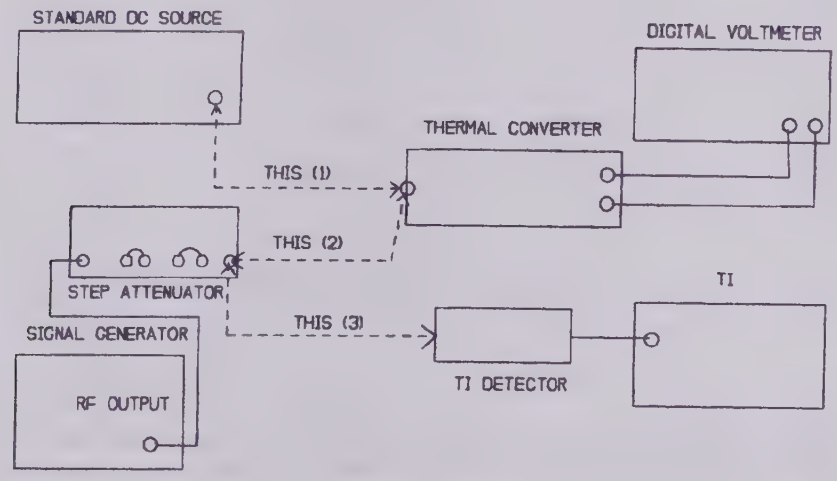

Figure 1.

4.1.4 Set Step Attenuator ATTENUATION controls to 0 dB.

4.1.5 Ensure that the DC Voltage source output controls are set to minimum.

4.1.6 Connect the Thermal Converter to the DC Voltage source output connectors Figure 1 (1).

4.1.7 Slowly increase the DC Voltage source controls to 670.82 mV (9 mW).

4.1.8 With the Digital Voltmeter measure and record the voltage out of the Thermal Converter.

4.1.9 Slowly reduce the DC Voltage output to minimum and disconnect the Thermal Converter.

4.1.10 Connect the Thermal Converter to the Step Attenuator. Figure 1 (2).

4.1.11 Increase the Signal Generator output level until the Digital Voltmeter indicates the value recorded in step 4.1.8.

4.1.12 Disconnect the Thermal Converter from the Step Attenuator.

4.1.13 Connect TI Detector to the Step Attenuator. Figure 1 (3).

4.1.14 The TI meter must indicate between 8.60 to 9.33 mW.

4.1.15 Set Step Attenuator to values listed in Applied column of Table 2.

4.1.16 Set TI POWER RANGE switches to values listed in Range column of Table 2.

4.1.17 TI meter must indicate within values listed in Limits column of Table 2 for each setting of Step Attenuator and Range switch setting.

Table 2.

Step Attenuator	Applied	TI Range	Limits *
10	.9 mW	1 mW	0.84 to 0.96 mW
20	90 µW	100 µW	81.96 to 98.73 µW
30	9 µW	10 µW	8.01 to 10.10 µW
40	.9 µW	1 µW	.78 to 1.03 µW
50	90 nW	100 nW	76.46 to 105.6 nW
60	9 nW	10 nW	7.42 to 10.87 nW

* Limits include Step Attenuator accuracies.

4.1.18 Disconnect equipment.

4.2 RF POWER CALIBRATION:

4.2.1 Determine the owning organization's frequency calibration requirements for the TI. The TI may be calibrated at every cardinal frequency available on the F1109N Standard Thermistor Mount between 10 MHz and 18 GHz, however, the minimum acceptable calibration of the TI shall consist of the following frequency calibration points:

a. Lowest frequency of interest, or F1109N cardinal frequency just below the lowest frequency of interest.

b. Highest frequency of interest, or F1109N cardinal frequency just above the highest frequency of interest.

c. Intermediate frequencies at every octave, or at every F1109N cardinal frequency that is an approximate octave step between the lowest and highest frequencies of interest.

4.2.2 Connect equipment as shown in Figure 2. On the rear panel of the RF Sweeper, set the AM/PWR MTR POLARITY switch to + and set the INPUT switch to AM/PWR MTR.

4.2.3 Press the RESET/LOCAL key on the Source Locking Counter, then press BAND, then 2.

4.2.4 Press the SWEEP EXT key on the RF Sweeper to select the Ext Sweep Menu and make the following selections using the DATA ENTRY and ENTR keys:

POWER	10.0 dBm
BANDX DLYS	YES

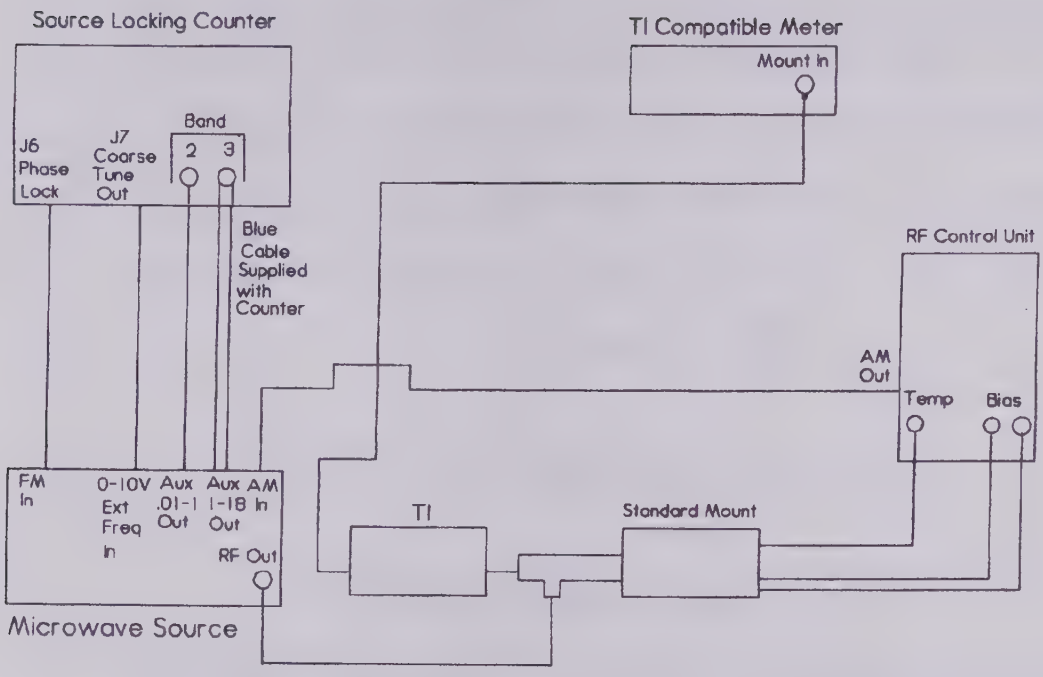

Figure 2.

4.2.5 Press the CNFIG key on the RF Sweeper to select the Configuration Menu and make the following selections using the DATA ENTRY and ENTR keys:

PRESTRT RF	NO	FM MOD	YES
RETRACE RF	NO	AM MOD	YES
RF MARKERS	NO	1 kHz MOD	NO
BLNK RETCE	NO	SWP FLTR	YES
BLNK BANDX	YES	MAX POWER	NO
BLNK MKRS	NO	EXT LEVEL	NO
AUX OUT	YES	PREC LEVEL	NO
		PULSE MOD	NO

4.2.6 Set the RF switch to OFF on the RF Control Unit and adjust the COARSE and FINE NULL controls to null the BRIDGE BALANCE METER. At this time, the TEMP indicator must be in the GREEN area, and the L.E.D. must be extinguished. Set the DC SUBSTITUTED POWER switch to 1 mW. Set the TI 10 mW (10 dBm) RANGE switch IN.

4.2.7 Press the RF Sweeper ON/OFF key to turn on the RF, and set the RF Control Unit switch to ON. On the Source Locking Counter, press the LOCK key, then enter 10 or the lowest frequency of interest, then press the MHz key. The Counter should lock the RF Sweeper to the frequency selected as indicated by a steady LCK annunciator on the Source Locking Counter display.

4.2.8 Observe that the RF Control Unit acquires a power lock and that the BRIDGE BALANCE METER indicates a null ±2.5 µW.

4.2.9 Increase power with the DC SUBSTITUTED POWER switch to 7 mW or the highest level while maintaining power and frequency lock.

4.2.10 Calculate the incident power being applied to the TI using:

$$IPmW = \frac{7mW}{CF}$$

Where: 7 mW = DC Sub power selected
CF = Cal Factor vs. frequency of Standard Mount

NOTE

If 7 mW is not obtainable, use maximum available power that is within the locking range of the source below 7 mW level.

4.2.11 Calculate the TI Calibration Factor in dBm using the following formula, or vary TI CAL FACTOR control until TI indicates as close as possible to the incident power calculated in step 4.2.10.

$$CF = -10\ Log\ \frac{TI\ Indication}{IP}$$

Where: TI INDICATION = Power indicated on the TI in mW.
IP = Incident Power calculated in step 4.2.10

4.2.12 Record the CAL FACTOR control settings vs frequency on a Calibration Data Chart in accordance with the instructions of T.O. 00-20-14.

4.2.13 Repeat steps 4.2.9 through 4.2.12 for the remaining frequencies of interest up to 1 GHz. Press the GHz key instead of the MHz key when required.

4.2.14 On the Source Locking Counter, press the BAND and 3 keys, then enter 2 (or the next frequency of interest above 1 GHz), and then press the GHz key. The counter should lock the RF Sweeper to the frequency selected as indicated by a steady LCK annunciator on the Source Locking Counter display.

4.2.15 Repeat steps 4.2.10 through 4.2.12 for the remaining frequencies of interest up to 18 GHz.

4.2.16 Press the ON/OFF key on the RF Sweeper to turn off the RF, and set the RF switch on the RF Control Unit to OFF.

4.2.17 If desired, the Source Locking Counter, RF Sweeper, RF Control Unit and Standard Thermistor Mount connections may be maintained for later use. If this is the case, set the POWER switch on the RF Control Unit to STANDBY. Otherwise, set all POWER switches to OFF and disconnect the set-up of Figure 2.

CALIBRATION PERFORMANCE TABLE

Not Required

ENGINEERING ASSISTANCE REQUEST

MANUFACTURE PART NUMBER	TEST SYSTEM	SPEC NUMBER	EAR NUMBER

REQUESTING DEPARTMENT

DEPT. or WORKGRP:	**ERS Location:**
ORIGINATOR:	**Date:**
Current Method or Problem:	
Recommendation and action taken to correct method or problem:	
Supervisor:	**Date:**
Submitted By:	**Date:**

EAR PRIORITY & CLASSIFICATION (check one)

PRIORITY: **HIGH** **NORMAL** **LOW**

CLASSIFICATION: DOCUMENT SOFTWARE DRAWING FIXTURE OTHERS
STATUS: ACCEPTANCE RE-RETURN

ENGINEERING DEPARTMENT

Assigned to:	**Date:**
Action taken by engineer:	
Completed by:	**Date:**
Verified by:	**Date:**
Closed by:	**Date:**

TECHNICAL MANUAL

CALIBRATION PROCEDURE

FOR

RF MICROWATTMETER

42BD RF MICROWATTMETER

W/41 - 41, 41 - 4B, & 41 - 4E POWER DETECTORS

(BOONTON)

This publication replaces T.O. 33K4-4-254-1 dated 9 May 1990.

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Published under Authority of the Secretary of the Air Force

30 MAY 1996

42BD RF MICROWATTMETER

W/41 - 41, 41 - 4B, 41 - 4E POWER DETECTORS

(BOONTON)

1 CALIBRATION DESCRIPTION:

Table 1.

Test Instrument (TI) Characteristics	Performance Specifications	Test Method
Frequency	Range: 0.2 MHz to 18 GHz (41-4E) 0.2 MHz to 12.4 GHz (41-4B) 0.2 MHz to 7.0 GHz (41-4A) Accuracy: N/A	Not Calibrated
Power	Range: 1 nW to 10 mW -60 to +10 dBm; -50 to +10 dBm for Opt 90 Accuracy: ±digit plus detector error	Compared to a Standard Power Measuring System
Power Detector Error	Range: 1 nW to 10 mW Accuracy: ±0.4 dB, 0.2 to 4 GHz; ±0.5 dB, 4 to 8.2 GHz; ±0.6 dB, 8.2 to 12.4 GHz; ±0.8 dB, 12.4 to 18 GHz Range: 10 nW to 10 mW Accuracy: ±0.2 dB, 0.2 to 4 GHz; ±0.3 dB, 4 to 8.2 GHz; ±0.4 dB, 8.2 to 12.4 GHz; ±0.6 dB, 12.4 to 18 GHz	Compared to a Standard Power Measuring System

2 EQUIPMENT REQUIREMENTS:

	Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.1	DC VOLTAGE STANDARD	Range: 0 to 3 VDC Accuracy: ±0.2%	Fluke 5440B	
2.2	DIGITAL VOLTMETER	Range: 0 to 1 Volt Accuracy: ±0.1%	Hewlett-Packard 3458A	

	Noun	Minimum Use Specifications	Calibration Equipment	Sub-Item
2.3	THERMAL CONVERTER	Range: 1 Volt Accuracy: ±0.08%	Hewlett-Packard 11050A	
2.4	SIGNAL GENERATOR	Range: 200 kHz Accuracy: ±1%	Hewlett-Packard 3325A	
2.5	STEP ATTENUATOR	Range: 0 to 50 dB Accuracy: ±0.1 dB	Weinschel 64A	
2.6	RF SWEEPER/ SYNCHRONIZING COUNTER	Range: 0 to 10 mW 10 MHz to 18 GHz Accuracy: Power N/A Frequency ±0.02%	EIP 931-9320/575-04	
2.7	POWER MEASUREMENT CALIBRATION SYSTEM	Range: 5 to 10 mW DC Sub power @ 10 MHz Accuracy: RF CONTROL UNIT: ±(0.01% + 5 µW) STANDARD MOUNT: Cal factors charted by AGMC on AFLC Form 5564	Weinschel PMCS-1B	Weinschel PMCS-1A

3 PRELIMINARY OPERATIONS:

3.1 Review and become familiar with the entire procedure before beginning calibration process.

WARNING

Unless otherwise designated, and prior to beginning the Calibration Process, ensure that all test equipment voltage and/or current outputs are set to zero (0) or turned off, where applicable. Ensure that all equipment switches are set to the proper position before making connections or applying power.

3.2 Be sure the serial number of the Power Detector is the same as the Model 42BD Power Meter. Each TI is calibrated with its particular 42B Detector.

3.3 Set TI rear panel POWER switch to 115 Volts.

3.4 Connect TI to a 115 Volt 60 Hz power source. Set POWER switch to ON and allow a 5 minute warm-up.

3.5 Depress TI -50 dBm FULL SCALE switch.

NOTE

Because of the TI's sensitivity on the -50 dBm range, meter pointer fluctuations of up to ±0.5 dB may be expected; proper zero adjustment is achieved when the "-" sign of the digital display flashes on and off at an equal rate.

3.7 Use only that portion of the calibration process which pertains to the TI under calibration.

4 CALIBRATION PROCESS:

NOTE

Unless otherwise specified, verify the results of each test and take corrective action whenever the test requirement is not met, before proceeding.

4.1 POWER CALIBRATION @ 200 kHz:

4.1.1 Set Signal Generator OUTPUT controls for minimum output, and FREQUENCY controls for 200 kHz.

4.1.2 Depress TI 10 mW FULL SCALE button and set CAL FACTOR control to 0 dBm.

4.1.3 Connect equipment as shown in Figure 1.

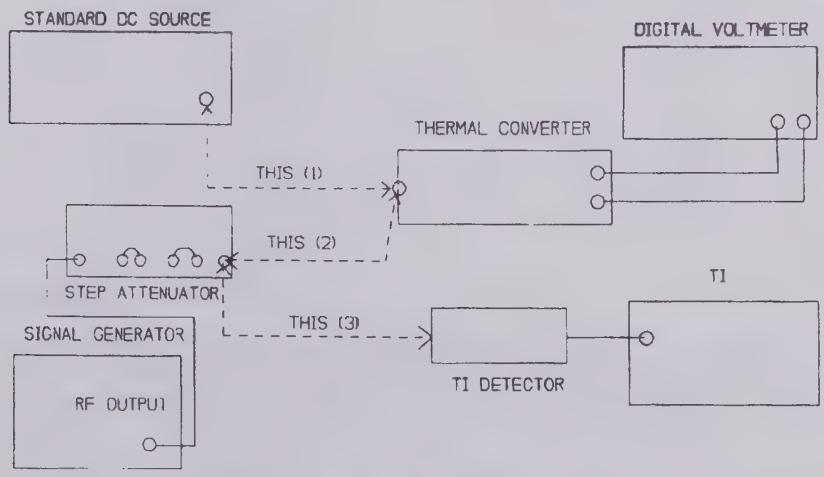

Figure 1.

4.1.4 Set Step Attenuator ATTENUATION controls to 0 dB.

4.1.5 Ensure that the DC Voltage source output controls are set to minimum.

4.1.6 Connect the Thermal Converter to the DC Voltage source output connectors Figure 1 (1).

4.1.7 Slowly increase the DC Voltage source controls to 630.19 mV (+9 dBm).

4.1.8 With the Digital Voltmeter measure and record the voltage out of the Thermal Converter.

4.1.9 Slowly reduce the DC Voltage output to minimum and disconnect the Thermal Converter.

4.1.10 Connect the Thermal Converter to the Step Attenuator, Figure 1 (2).

4.1.11 Increase the Signal Generator output level until the Digital Voltmeter indicates the value recorded in step 4.1.8.

4.1.12 Disconnect the Thermal Converter from the S ep Attenuator.

4.1.13 Connect TI Detector to the Step Attenuator, Figure 1 (3).

4.1.14 The TI meter must indicate between 7.587 to 8.318 mW + 1 digit.

4.1.15 Set Step Attenuator to values listed in Applied column of Table 2.

4.1.16 Depress TI POWER RANGE buttons to values listed in Range column of Table 2.

4.1.17 TI meter must indicate within values listed in Limits column of Table 2 for each setting of Step Attenuator and Range switch setting.

Table 2.

Applied (dBm)	Power Range	Limits
10	1 mW	0.759 to 0.832 mW
20	100 µW	.0759 to .0832 mW
30	10 µW	7.586 to 8.318 µW
40	1.0 µW	.7586 to .8318 µW
50	100 nW	75.86 to 83.18 nW

4.1.18 Disconnect equipment.

4.2 RF POWER CALIBRATION:

4.2.1 Determine the owning organization's frequency calibration requirements for the TI. The TI may be calibrated at every cardinal frequency available on the F1109N Standard Thermistor Mount between 10 MHz and 18 GHz, however, the minimum acceptable calibration of the TI shall consist of the following frequency calibration points:

a. Lowest frequency of interest, or F1109N cardinal frequency just below the lowest frequency of interest.

b. Highest frequency of interest, or F1109N cardinal frequency just above the highest frequency of interest.

c. Intermediate frequencies at every octave, or at every F1109N cardinal frequency that is an approximate octave step between the lowest and highest frequencies of interest.

4.2.2 Connect equipment as shown in Figure 2. On the rear panel of the RF Sweeper, set the AM/PWR MTR POLARITY switch to + and set the INPUT switch to AM/PWR MTR.

4.2.3 Press the RESET/LOCAL key on the Source Locking Counter, then press BAND, then 2.

4.2.4 Press the SWEEP EXT key on the RF Sweeper to select the Ext Sweep Menu and make the following selections using the DATA ENTRY and ENTR keys:

POWER	10.0 dBm
BANDX DLYS	YES

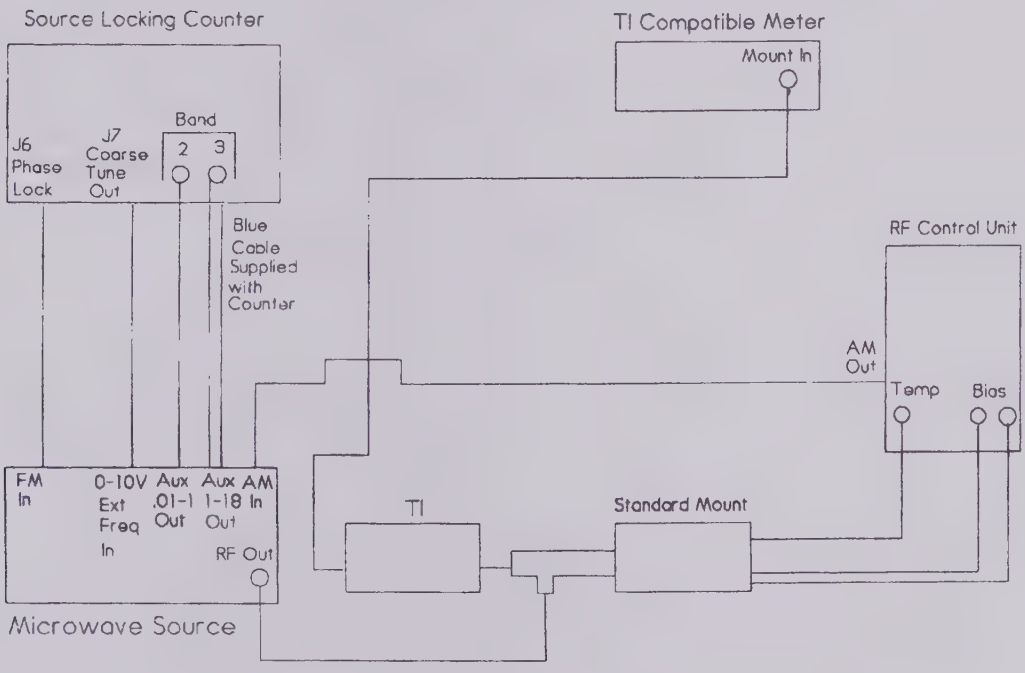

Figure 2.

4.2.5 Press the CNFIG key on the RF Sweeper to select the Configuration Menu and make the following selections using the DATA ENTRY and ENTR keys:

PRESTRT RF	NO	FM MOD	YES
RETRACE RF	NO	AM MOD	YES
RF MARKERS	NO	1 kHz MOD	NO
BLNK RETCE	NO	SWP FLTR	YES
BLNK BANDX	YES	MAX POWER	NO
BLNK MKRS	NO	EXT LEVEL	NO
AUX OUT	YES	PREC LEVEL	NO
		PULSE MOD	NO

4.2.6 Set the RF switch to OFF on the RF Control Unit and adjust the COARSE and FINE NULL controls to null the BRIDGE BALANCE METER. At this time, the TEMP indicator must be in the GREEN area, and the L.E.D. must be extinguished. Set the DC SUBSTITUTED POWER switch to 1 mW. Depress the TI 10 mW (10 dBm) button.

4.2.7 Press the RF Sweeper ON/OFF key to turn on the RF, and set the RF Control Unit switch to ON. On the Source Locking Counter, press the LOCK key, then enter 10 or the lowest frequency of interest, then press the MHz key. The Counter should lock the RF Sweeper to the frequency selected as indicated by a steady LCK annunciator on the Source Locking Counter display.

4.2.8 Observe that the RF Control Unit acquires a power lock and that the BRIDGE BALANCE METER indicates a null ±2.5 μW.

4.2.9 Increase power with the DC SUBSTITUTED POWER switch to 7 mW or the highest level while maintaining power and frequency lock.

4.2.10 Calculate the incident power being applied to the TI using:

$$IPmW = \frac{7mW}{CF}$$

Where: 7 mW = DC Sub power selected

CF = Cal Factor vs. frequency of Standard Mount

NOTE

If 7 mW is not obtainable, use maximum available power that is within the locking range of the source below 7 mW level.

4.2.11 Calculate the TI Calibration Factor in dBm using the following formula, or vary TI CAL FACTOR control until TI indicates as close as possible to the incident power calculated in step 4.2.10.

$$CF = -10\ Log\ \frac{TI\ Indication}{IP}$$

Where: TI INDICATION = Power indicated on the TI in mW.
IP = Incident Power calculated in step 4.2.10

4.2.12 Record the CAL FACTOR control settings vs frequency on a Calibration Data Chart in accordance with the instructions of T.O. 00-20-14.

4.2.13 Repeat steps 4.2.9 through 4.2.12 for the remaining frequencies of interest up to 1 GHz. Press the GHz key instead of the MHz key when required.

4.2.14 On the Source Locking Counter, press the BAND and 3 keys, then enter 2 (or the next frequency of interest above 1 GHz), and then press the GHz key. The counter should lock the RF Sweeper to the frequency selected as indicated by a steady LCK annunciator on the Source Locking Counter display.

4.2.15 Repeat steps 4.2.10 through 4.2.12 for the remaining frequencies of interest up to 18 GHz.

4.2.16 Press the ON/OFF key on the RF Sweeper to turn off the RF, and set the RF switch on the RF Control Unit to OFF.

4.2.17 If desired, the Source Locking Counter, RF Sweeper, RF Control Unit and Standard Thermistor Mount connections may be maintained for later use. If this is the case, set the POWER switch on the RF Control Unit to STANDBY. Otherwise, set all POWER switches to OFF and disconnect the set-up of Figure 2.

CALIBRATION PERFORMANCE TABLE

Not Required

INSTRUCTION MANUAL
MODELS 42BD & 42CD

R.F. MICROWATTMETERS

This instruction manual applies to instruments
with serial numbers 2039 and above.

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ELECTRONICS CORPORATION

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P/N 981002-01A

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation and maintenance of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Boonton Electronics assumes no liability for the customer's failure to comply with these requirements.

THE INSTRUMENT MUST BE GROUNDED
To minimize shock hazard the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three conductor, three prong a.c. power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to a two-contact adapter with the (green) grounding wire firmly connected to an electrical ground at the power outlet.

DO NOT OPERATE THE INSTRUMENT IN AN EXPLOSIVE ATMOSPHERE.
Do not operate the instrument in the presence of flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS.
Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by quailfied maintenance personnel. Do not replace components with the power cable connected. Under certain conditions dangerous voltages may exist even though the power cable was removed, therefore; always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE.
Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT.
Do not install substitute parts or perform any unauthorized modification of the insturment. Return the instrument to Boonton Electronics for repair to ensure that the safety features are maintained.

SAFETY SYMBOLS.

This safety requirement symbol (located on the rear panel) has been adopted by the International Electrotechnical Commission, Document 66 (Central Office) 3, Paragraph 5.3, which directs that and instrument be so labeled if, for the correct use of the instrument, it is necessary to refer to the instruction manual. In this case it is recommended that reference be made to the instruction manual when connecting the instrument to the proper power source. Verify that the correct fuse is installed for the power available, and that the switch on the rear panel is set to the applicable operating voltage.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operation procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the equipment. Do not proceed beyond a CAUTION sign until the indicated conditions are fully understood and met.

WARNING

The WARNING sign denotes a hazard. It calls attention to an operation procedure, practice, or the like, which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a WARNING sign until the indicated conditions are fully understood and met.

Indicates dangerous voltages.

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SECTION I

GENERAL DESCRIPTION

1-1. INTRODUCTION.

This instruction manual provides general information, installation and operating instructions, theory of operations, maintenance instructions, a parts lists, and schematics for the Model 42BD and 42CD.

SAFETY NOTICE

Although this instrument has been designed in accordance with international safety standards, general safety precautions must be observed during all phases of operation and maintenance of the instrument. Failure to comply with the precautions listed in the Safety Summary located in the front of this manual could result in serious injury or death. Service and adjustment should be performed only by qualified service personnel.

1-2. DESCRIPTION

A. General. This instruction manual applies to Models 42BD and 42CD digital microwattmeters. These instruments differ only in their power ranges (10 nW - 10 mW f.s. for the 42BD, 100 nW - 100 mW f.s. for the 42CD) and their power sensors (series 41-4 for the 42BD, series 41-5 for the 42CD). To avoid repetition, 42BD is used throughout the manual; it is to be understood that the information applies as well to the 42CD. In those places where data for the two differ, the first datum given applies to the 42BD and the datum for the 42CD follows in brackets [ ].

The 42BD R.F. Digital Microwattmeter determines r.f. power by measuring the voltage appearing across a precision noninductive resistor in the Power Sensor. The digital readout is calibrated in terms of power according to the relationship $P = E^2/R$. This detection system has important performance advantages over power meters using bolometer or thermocouple detection. The sensitivity is several orders of magnitude better; temperature stability of better than 0.01 dB/°C supports this sensitivity; and a burnout level above 300 mW [2 W] reduces the most common cause of detector failure.

This instrument is available with a number of options and Power Sensors. For all options, input-range programming can be controled by TTL logic or pnp transistors to ground. It is packaged as a compact bench instrument, with a combination carrying handle and adjustable-angle mounting foot. Should rack mounting be preferred, hardware kits to accommodate either one or two instruments are available.

B. Frequency Range. The calibrated frequency range extends from 0.2 MHz to 18 GHz, depending upon the particular sensor used. Useful response for relative measurements can be obtained from 20 kHz to approximately 20 GHz.

C. Power Range. With any of the sensors, the Model 42BD will measure power from 1 nW [10 nW] up to 10 mW [100 mW]. Temporary overloads up to 300 mW [2 W] will do no permanent harm to the instrument or the sensor. When measuring pulsed signals, the accuracy is good up to 35 µW [350 µW] instantaneous peak power. The power capabilities of the 42BD can be increased by the use of external attenuators.

§1-2, continued.

D. Response. At low power levels the sensor diodes operate in the square-law region; the instrument response is to the true average power of c.w., a.m., f.m., and pulsed signals. Above the transition level of approximately 20 µW [200 µW] average power, although response tends toward the peak value, the panel meter is calibrated in terms of average power; the instrument will correctly indicate the true average power of c.w. and f.m. signals.

E. Noise. The 42BD has been designed and constructed to hold noise from all sources to a minimum. The Power Sensor cable is of special low-noise design; a vigorous flexing causes only momentary, minor deflection on the most sensitive range of the instrument. The Power Sensor is not sensitive to shock or vibration; even sharp tapping on its barrel causes no visible deflection on any range.

F. Zero Adjustment. Zero adjustment is normally not required on the upper ranges of the 42BD. For measurement on the lower ranges, the ZERO control is adjusted on the instrument's most sensitive range before using. This control balances out small thermal voltages in the sensing elements and, once adjusted, requires only infrequent checking during the course of subsequent measurements.

G. Calibration-Factor Adjustment. A panel-mounted control allows the sensitivity of the 42BD to be adjusted to correct for the frequency response and mismatch errors of the sensor. Calibration is in the form of indicated power to incident power.

The front-panel scale for the control is graduated in 0.1 dB steps; the resolution of the control, however, is 0.01 dB (as indicated by the digital display).

H. Analog Output. The 42BD provides a d.c. output voltage proportional to the power being measured. The current capability of 1 mA in 1000 ohms is extremely stable. When used as part of an automatic test system, it is necessary to allow a settling time for the d.c. output level to reach final value after a step function in r.f. input. The settling time varies with the range and the size of the step.

I. BCD Output. The 42BD provides a bit-parallel digit-serial binary-coded-decimal output (4-line, 8-4-2-1), for connection to an external system. Ranges can also be remotely controlled and the BCD output can be triggered in synchronism with some system event. Option -21, a buffered serial-to-parallel BCD converter, can be installed on the rear to provide a 16-line output. The serial-parallel converter is not used when connecting to the Model 10A-01 Bus Interface Unit.

All input and output connections are made at the card-edge connector at the rear of the instrument case.

J. Bus Interface. The optional Model 10A-01A IEEE-488 Bus Interface Unit allows the 42BD to be adapted for use within a system on the bus. It permits the 42BD to become either a talker or a listener, or both, under the direction of a controller such as a bus-interfaceable computer.

The 10A-01A can be installed either alongside or to the rear of the 42BD. Two rack-mounting kits are available.

A line input is required by the 10A-01, but an on-off switch is not needed. The unit senses when the 42BD is on or off, switching itself accordingly.

1-3. ACCESSORIES FURNISHED

Model 41-2A, five-foot power-detector cable. Longer cables are available on special order.

1-4. REQUIRED ACCESSORIES

One of the following Power Sensors should be ordered with the instrument. See Specifications, §1-7, for details.

A. For Model 42BD: Sensor 41-4A, 41-4B, 41-4C, or 41-4E.
B. For Model 42CD: Sensor 41-5B or 41-5E.

1-5. ACCESSORIES AVAILABLE

A. Model 950030, Double Rack-Mounting Kit. Kit for mounting two 42BD's side by side in a standard 19-inch rack.

B. Model 950032, Single Rack-Mounting Kit. Kit for mounting one 42BD as one half of a module in a standard 19-inch rack.

C. Model 960000, Extender Card. Allows plug-in printed-circuit board to be operated in elevated position (to facilitate servicing).

1-6. OPTIONS

A. Option -01, Autoranging option. Automatically selects the proper range for the applied input. Can be manually selected, or programmed. Upranges at approximately 103% of f.s.; downranges at approximately 9.5% of f.s. 100 ms/range change.

B. Option -08, Rear-Signal Input option. A duplicate connector for the sensor cable is provided on the rear panel of the instrument.

C. Option -09, dBm Display. Power display or dBm display can be manually selected or programmed. Separate logic-level outputs are provided to indicate whether the output data represent power or dBm.

D. Option -21, Buffered Serial-to-Parallel BCD Converter option. Rear plug-in accessory to convert serial data output to parallel data output; DTL & TTL compatible.

1-7. SPECIFICATIONS

POWER RANGE:	42BD	1 nW (-60 dBm) to 10 mW (+10 dBm), 7 decades
	42CD	10 nW (-50 dBm) to 100 mW (+20 dBm), 7 decades
FULL-SCALE POWER RANGES:		
	42BD	10 nW, 100 nW, 1 µW, 10 µW, 100 µW, 1 mW, 10 mW
	42CD	100 nW, 1 µW, 10 µW, 100 µW, 1 mW, 10 mW, 100 mW
FREQUENCY RANGES (with indicated Power Sensor):		
	42BD	Model 41-4E (50 Ω): 0.2 MHz to 18.0 GHz
		Model 41-4B (50 Ω): 0.2 MHz to 12.4 GHz
		Model 41-4A (50 Ω): 0.2 MHz to 7.0 GHz
		Model 41-4C (75 Ω): 0.2 MHz to 1.0 GHz
	42CD	Model 41-5E (50 Ω): 0.2 MHz to 18.0 GHz
		Model 41-5B (50 Ω): 0.2 MHz to 12.4 GHz
INSTRUMENT ACCURACY:		
	Power	±(0.25% f.s. + 0.15 dB) above 10 nW [100 nW]
		±(1.0% f.s. + 0.15 dB) below 10 nW [100 nW]
	dB Option	±(0.25% f.s. + 0.25 dB) above -50 dBm [-40 dBm]
		±(1.0% f.s. + 0.15 dB) below -50 dBm [-40 dBm]

CALIBRATION-FACTOR CONTROL: Variable ±1 dB

§1-7, continued.

INDICATORS:

	Digital	LED, 3 1/2 digits, f.s. count of 1000. (Full four-digit display with dBm option, 0.01 dB resolution.) Blanks at approximately 5% over f.s. & below approximately 10% f.s. Decimal point, units annunciators, polarity for dBm. Display period: 200 ms. Encode period: 75 ms.
	Analog	Miniature edgewise type, calibrated 0 to -10 dBm.

ZERO DRIFT:

42BD	1 nW/hr max., on 10 nW range
42CD	10 nW/hr max., on 100 nW range

WAVEFORM RESPONSE:

42BD	1 nW to 20 µW, true average power; above 20 µW, average power of sine wave.
42CD	10 nW to 200 µW , true average power; above 200 µW, average power of sine wave.

D.C. OUTPUT: 0 to 10 V on each range, proportional to input power; 9 kΩ source, 1 mA max. into 1 kΩ.

TEMPERATURE INFLUENCE:

Temperature Range	Effect Instrument	Effect Sensor
21°C to 25°C	0 dB	0 dB
18°C to 30°C	0	±0.1
10°C to 40°C	±0.2	±0.2

R.F.I.: No detectable radiated or conducted leakage from instrument or sensor.

INPUT STEP-FUNCTION RESPONSE TIME: F.s., 10 µW to 10 mW [100 µW to 100 mW], 100 ms; f.s., 10 nW to 1 µW [100 nW to 10 µW], 1 s.

COMMANDS: TTL-logic-level zero selects Manual Disable, Encode, Trigger, Encode Hold and Input Range. With options, selects Power or dBm, & Autorange.

DATA OUTPUTS: 1-2-4-8 BCD Data, serial by digits; 1-2-4 Range information; Overrange, Underrange, Encode Complete. TTL levels.

POWER: 115 or 230 V ±10%, 50 - 400 Hz, 15 W.

DIMENSIONS: 132 mm high (without feet) × 211 wide × 305 deep (5.2 in. × 8.3 × 12).

WEIGHT:

Net	4.3 kg (9.5 lb), with sensor and cable
Shipping	5.7 kg (12.5 lb)

POWER SENSORS: See Table 1-1.

Table 1-1. Power-Sensor Specifications

MODEL	41-4A	41-4B	41-4C	41-4E	41-5B	41-5E
INPUT	50 Ω	50 Ω	75 Ω	50 Ω	50 Ω	50 Ω
FREQUENCY RANGE	200 kHz-7 GHz	200 kHz-12.4 GHz	200 kHz-1 GHz	200 kHz-18 GHz	200 kHz-12.4 GHz	200 kHz-18 GHz
POWER RANGE	10 nW to 10 mW, f.s.				100 nW to 100 mW, f.s.	
SUM OF CALIBRATION-FACTOR UNCERTAINTIES	1%, 200 kHz-300 MHz 1.3%, 300 MHz-2 GHz 3.0%, 2 GHz-4 GHz 3.5%, 4 GHz-7 GHz	1%, 200 kHz-300 MHz 1.3%, 300 MHz-2 GHz 3%, 2 GHz-4 GHz 3.5%, 4 GHz-8 GHz 4.0%, 8 GHz-10 GHz 4.5%, 10 GHz-12 GHz 6.0%, 12 GHz-18 GHz				
MAXIMUM S.W.R.	1.12, 200 kHz-2 GHz 1.2, 2 GHz-4 GHz 1.4, 4 GHz-7 GHz	41-4A, -4B, -4C, -4E: Add 0.05 dB/mW above 4 GHz 1.12, 200 kHz-2 GHz 1.2, 2 GHz-4 GHz 1.4, 4 GHz-11 GHz 1.6, 11 GHz-12.4 GHz	1.18, 200 kHz-1 GHz	1.3, 200 kHz-4 GHz 1.5, 4 GHz-10 GHz 1.7, 10 GHz-18 GHz	41-5B, -5E: Add 0.005 dB/mW above 4 GHz 1.07, 200 kHz-1 GHz 1.10, 1 GHz-2 GHz 1.12, 2 GHz-4 GHz 1.18, 4 GHz-12.4 GHz	1.07, 200 kHz-1 GHz 1.10, 1 GHz-2 GHz 1.12, 2 GHz-4 GHz 1.18, 4 GHz-12.4 GHz 1.28, 12.4 GHz-18 GHz
MAXIMUM AVERAGE POWER	10 mW (+10 dBm)				100 mW (+20 dBm)	
OVERLOAD RATING	300 mW (+25 dBm)				2 W (+33 dBm)	
R.F. CONNECTOR	Precision Type N male					
CALIBRATION FACTOR	Individually calibrated at up to nine frequencies, depending upon sensor.					

SECTION II

INSTALLATION & OPERATION

2-1. INSTALLATION

The 42BD has been inspected and tested at the Factory before packing, and it is shipped ready for operation. If there is any indication of shipping damage, immediately notify the carrier before you attempt to put the 42BD into operation.

2-2. OPERATING CONTROLS AND INDICATORS

All controls, indicators and connectors used during operation of the 42BD are described in Table 2-1, below.

Table 2-1. Operating Controls, Indicators, and Connectors

ITEM	FUNCTION
OFF/PWR/dBm Selector Switch	Turns "on" instrument power; if dBm option is installed, selects power or dBm readout.
FULL SCALE Pushbuttons	Select operating range (PWR or dBm). The AUTO pushbutton, with -01 option installed, switches 42BD to automatic ranging mode.
Indicators	Digital (LED): 3 1/2 digits, decimal point, units (-09 option:4 digits, decimal pt., units, polarity) Analog: meter, calibrated -10 to 0 dBm.
POWER SENSOR	The sensor cable connects to the 42BD through this jack. Always check that the knurled ferrule nut of the sensor-cable connection is tightened.
ZERO Control	This control, the center portion of the OFF/PWR/dBm switch, is used to electrically "zero" the 42BD.
CAL FACTOR	Compensates for frequency effect at f > 1 GHz.
Fuse Holder (Rear Panel)	Line fuse. For 115 V, 0.20 A; for 220 V, 0.10 A; either fuse to be MDL SLO-BLO.
Slide Switch (Rear Panel)	Switch is to be set to 115 or 230 V, according to the available line voltage.
Recorder Output (Rear Panel)	A d.c. voltage proportional to the applied power level is available at these terminals.
REMOTE CONNECTIONS (Rear Panel)	The card-edge plug is intended for use with an Amphenol 225-22221-101 connector, or equivalent. See Table 2-2 for pin designations.

2-3. SAFETY REQUIREMENT SYMBOL

This safety requirement symbol (on the rear panel) has been adopted by the International Electrotechnical Commission, Document 66 (Central Office) 3, Paragraph 5.3, which directs that an instrument be so labeled if, for the correct use of the instrument, it is necessary to refer to the instruction manual. In this case it is recommended that reference be made to the instruction manual when connecting the instrument to the proper power source. Verify that the correct fuse is installed for the power available, and that the switch on the rear panel is set to the applicable operating voltage.

2-4. INITIAL OPERATING PROCEDURES

A. Be sure that the serial number of the sensor to be used is the same as that of the instrument. (Each 42BD is calibrated for its particular sensor.) Use of a sensor other than that for which the instrument was calibrated may result in measurement errors.

B. Check the setting of the power switch on the rear panel to be sure that it is set to the proper position for the line voltage in use. See that the proper fuse for this voltage is installed in the fuseholder.

C. Connect the sensor cable to the POWER SENSOR front-panel jack; tighten the knurled clamping nut firmly. Attach the power sensor to the cable.

D. Set the CAL FACTOR control to 0 dB.

E. Plug the instrument's power cable into a power receptacle and turn the selector switch to PWR. Allow a few minutes for the 42BD to warm up.

F. Press the 10 nW [100 nW] FULL SCALE button. With no signal into the sensor, the pointer on the analog edgemeter can be adjusted with the ZERO control to the zero reference mark at the bottom of the scale. For greatest zero accuracy, however, adjust the ZERO control so that the minus sign (-) of the digital display flashes on and off at equal rates. If the sensor is in a strong power-line or noise field, zeroing may be difficult. In this situation, refer to §2-6G for shielding instructions.

For zeroing, it is important that the sensor be in thermal equilibrium. Consequently, prolonged handling of the sensor should be avoided within a few minutes before, or during, this adjustment.

2-5. OPERATING NOTE

The power sensors are carefully insulated against external temperature variations. However, when the most sensitive ranges of the instrument are in use, it is advisable to locate the sensor away from any sources of heat. If it is monitoring the output of equipment that generates heat significantly above ambient temperature, the sensor should be allowed to reach thermal equilibrium before measurements are made.

2-6. OPERATION

A. Low-Level Measurements. The 42BD will provide reliable, reproducible measurements of c.w., a.m., and f.m. power levels as low as 1 nW [10 nW]. It can also be used, although with slightly decreased accuracy (±1 dB), for pulse measurements. The peak power in this mode, however, should not exceed 35 µW [300 µW]. Above this level the detector enters the region where it ceases to function as a square-law detector; accuracy, except for c.w. and f.m., cannot be guaranteed under these conditions.

When using the three most sensitive ranges, the preliminary zero adjustment is required (see §2-4F).

§2-6, continued.

B. High-Level Measurements. When using the higher ranges of the 42BD, it is not necessary to make the zero adjustment. As noted in §2-6A, accuracy cannot be guaranteed when measuring pulse power with peaks exceeding 35 μW [300 μW]. For c.w. and f.m., power measurements within the specified accuracy will be obtained up to 10 mW [100 mW].

C. High-Frequency Measurements. To obtain the specified accuracy of the 42BD at frequencies above 1 GHz, reference must be made to the correction table on the barrel of the power sensor. This table, which is individually determined for each power sensor, presents a correction factor vs frequency that must be applied to the instrument reading. While this can be done by adding algebraically the correction to the reading, use of the CAL FACTOR control automatically inserts the correction and enables the operator to read the meter directly. This control is adjusted as follows:

Read the correction to be applied at the frequency of operation from the table on the sensor's barrel. As an example, say that the correction is +0.2 dB. Set the CAL FACTOR control to +0.2 dB. All values thereafter, at that frequency, are read directly from the meter, with no further correction needed. Note that if the frequency of measurement is changed, a new CAL FACTOR setting will be required.

NOTE: The Model 41-4A, 41-4B, 41-4E, 41-5B and 41-5E sensors are calibrated for use with a 50 Ω source. Deviations from 50 Ω may give rise to errors from mismatch and increased s.w.r. This effect can be reduced by inserting a low-s.w.r. attenuator (s.w.r. < 1.10) between the source and the sensor; an alternative would be the insertion of a low-loss tuner, or isolator.

The Model 41-4C sensor is calibrated for use with a 75 Ω source. Similar considerations apply for deviations from 75 Ω.

D. High-Frequency Errors. Power measurements, particularly at high frequencies, are fraught with a number of uncertainties. These include such questions as: What power do we want to measure? What power is being measured? How do we convert the indicated power to the wanted power?

If all power sources and power meters had impedances that were resistive and equal to Z_o (the characteristic impedance of the measuring system), most of these problems would disappear. The incident, dissipated, and maximum available powers would all be equal, and the indicated power would differ from them only by the inefficiency of the sensor in converting all of the dissipated power to indicated power. (This inefficiency is called the effective efficiency and, for a power sensor whose input impedance is resistive and equal to Z_o, it also defines the calibration factor.)

Unfortunately, perfect impedances are seldom the case, and the source impedance of power sources can depart substantially from Z_o. The use of attenuator pads can mask this departure, as can the use of a directional coupler to level the source and reduce its reflection coefficient to a value equal to the directivity factor of the coupler. No such control over the input impedance of a power sensor is possible without the use of attenuator pads, which sacrifice sensitivity and introduce other uncertainties.

1. Mismatch Error Correction Using Complex Reflection Coefficients.

When the complex reflection coefficients of both an imperfect source and the power sensor are known, a correction factor can be calculated and applied to the measured power, P_m, to obtain the power that would be dissipated in an ideal power sensor of impedance Z_o, if it were connected to the same source. The correction factor, m, equals:

$$m = \frac{P_0}{P_m} = \frac{(1 + \rho_g\rho_\ell{}^2 - \rho_g\rho_\ell - \rho_\ell)^2}{(1 - \rho_\ell)^2} \qquad (1)$$

Where

$P_m = \frac{P}{k}$ = measured power with 42BD

P_0 = measured and dissipated power in an ideal power meter (of Z_0)

P = indicated power on the 42BD

k = calibration factor for the power sensor

ρ_g = complex reflection coefficient of power source

ρ_ℓ = complex reflection coefficient of power sensor

The maximum power available from this source is:

$$P_a = \frac{P_0}{1 - |\rho_g|^2} \qquad (2)$$

Assume that the complex reflection coefficients are known to be ρ_g = 0.0909 $\angle 20°$ and ρ_ℓ = 0.111 $\angle -15°$. Assume also that the calibration factor for this power sensor at the operating frequency is -0.56 dB, or k = 1.138 (as determined from the incident power of a 50 Ω source). When the power meter and source are connected, the indicated power is 55.2 µW. Applying the calibration factor, P_m = 55.2/1.138 = 48.5 µW. The correction factor calculated from Equation (1) for the reflection coefficients given is 0.98. Thus, the power, P_0 that would be dissipated in an ideal power meter would be 0.98 × 48.5 µW, or 47.5 µW. The maximum available power from this source, from Equation (2), is:

$$47.5/(1 - |0.0909|^2) = 47.9 \text{ µW.}$$

Summary:
Power from an imperfect source is measured with a diode-sensor power meter. From the measurement obtained it is possible to predict the power that would have been measured with an ideal power meter.

a. Measure the power from the imperfect source with the diode-sensor power meter. Call the indicated power P.

b. Using the calibration factor, determine the measured power, P_m.

$$P_m = P/k$$

c. Knowing the complex reflection coeffiecients of the source and of the power meter, calculate m. See Equation (1).

d. Determine P_0 from: $P_0 = mP_m$.

e. The maximum available power from this source, P_a, is found with Equation (2).

2. Mismatch Uncertainties Where Only S.W.R. is Known.

When the complex reflection coefficients of both an imperfect source and the power sensor are unknown, and only the maximum or actual s.w.r. of both are known, the maximum positive and negative uncertainties of the measured power, P_m, can be determined from Figure 2-1. In the example given above, the s.w.r. of the source is known to be 1.2 and the s.w.r of the power sensor is 1.25. From Figure 2-1, the power measured by an ideal power meter connected to the same source may differ by ±2% from the power measured by the imperfect power meter--from 47.5 µW to 49.5 µW. The maximum power available from this source may be:

$$P_a = 47.5/0.99 = 48.0 \text{ µW, to } 49.5/0.99 = 50.0 \text{ µW}$$

3. When neither the complex reflection coefficients nor the s.w.r of both an imperfect source and the power sensor is known, the measured power cannot be defined as anything except the indicated power. If, however, the power-source impedance is Z_0, the calibration factor of the sensor can be applied to yield the incident power.

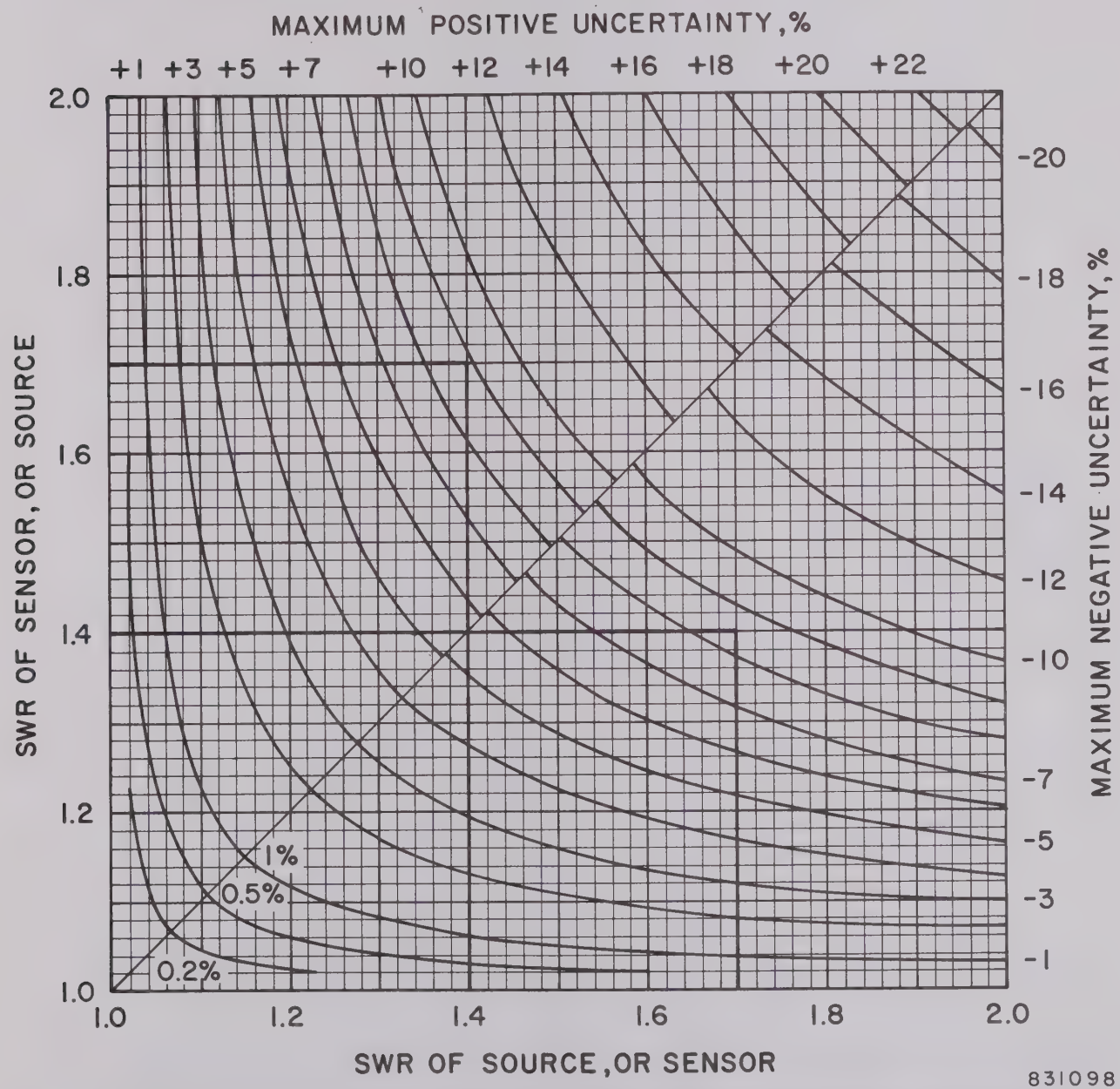


Figure 2-1. Uncertainty of Power Measurements as a Function of S.W.R.

E. Temperature Effects. The accuracy specifications for the 42BD apply over an ambient-temperature range of 18°C to 30°C. Operation outside this temperature range is possible, but some inaccuracy can be expected. Figure 2-2 shows a typical temperature characteristic of a power sensor, while the typical temperature characteristic of a 42BD and power sensor together is shown in Figure 2-3.

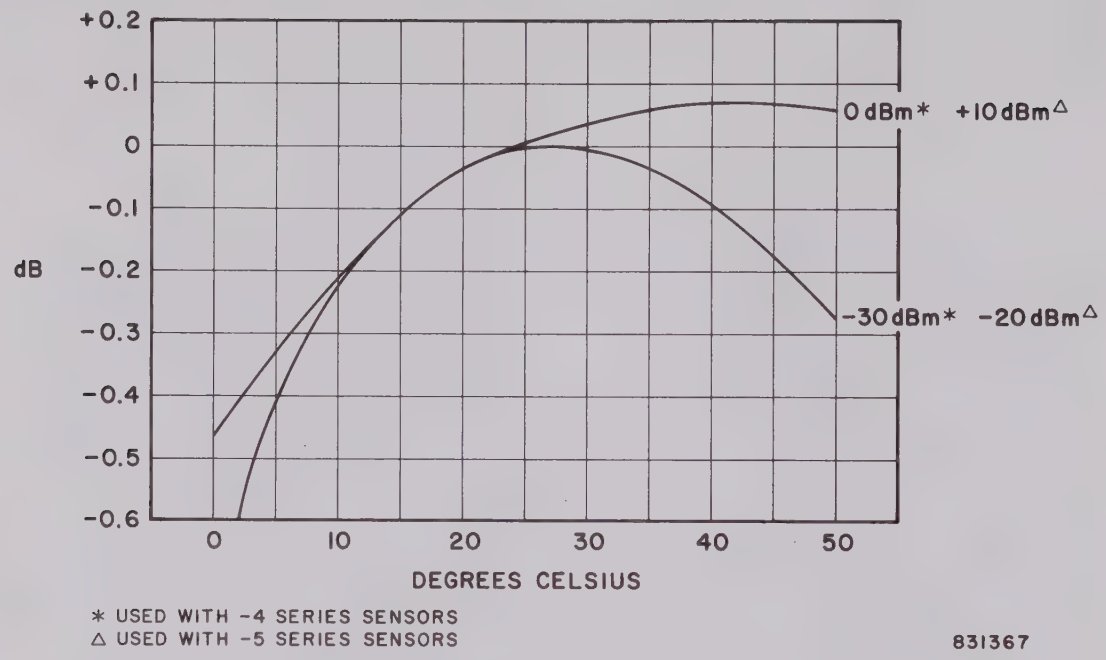


Figure 2-2. Typical Temperature Characteristic: Power Sensor Only

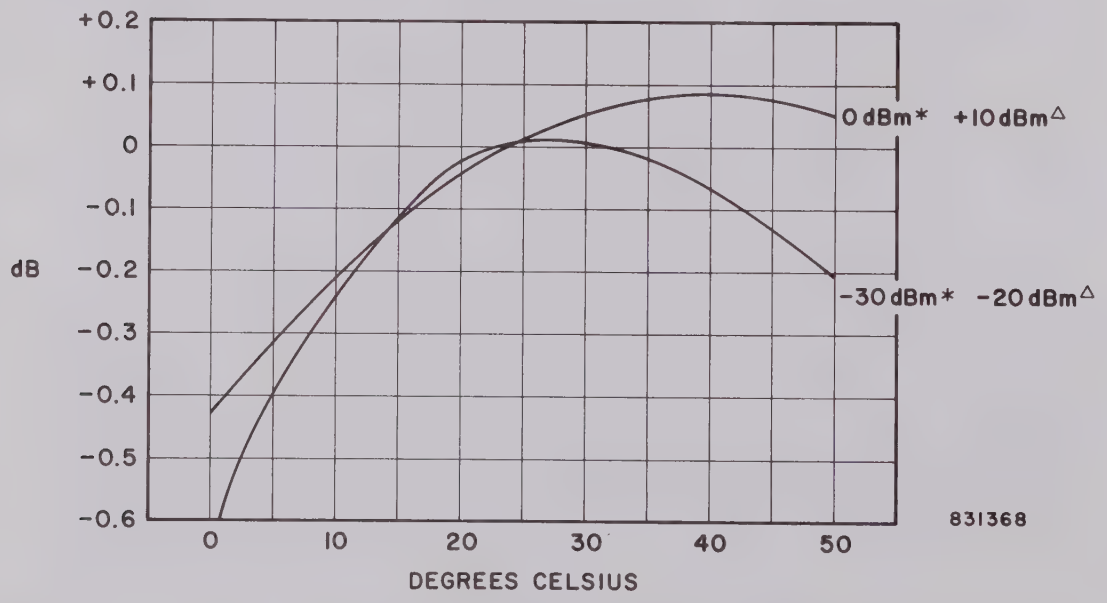


Figure 2-3. Typical Temperature Characteristics: Power Sensor and 42BD

F. S.W.R. Measurements. The high upper-frequency limits of the 42BD, and its sensitivity, make it a useful instrument for measuring s.w.r with a slotted line. As this type of measurement requires only comparative, rather than absolute values, the 41-4B [41-5B] sensor can be used up to 18 GHz and the 41-4E [41-5E] sensor can be used up to 20 GHz.

S.w.r. is determined by measuring the dB difference between a maximum and a minimum indicated power point on a slotted line, and converting the difference to s.w.r. An adapter is needed to couple the sensor to the slotted line; these are usually available from the manufacturer of the slotted line being used. Measurements are made as follows:

§2-6F, continued.

1. Connect the sensor to the slotted line's sliding carriage, using a suitable adapter.

2. With the signal source "off", zero the 42BD.

3. Turn the signal source "on", and slide the carriage along the line until a point of maximum reading is located.

4. Adjust the source level and the probe positioning for the least coupling that will yield a reading of -41 dBm [-31 dBm] at the maximum point. (The incident power should be 0 dBm or greater.)

5. Slide the carriage along the line until a point of minimum reading is located. Note the meter reading (dBm) at this point, then subtract this minimum reading from the maximum reading. Convert the resultant ΔdB into s.w.r. either by use of Figure 2-4, or by computation. (The s.w.r. is the antilog, base 10, of ΔdB/20.)

G. Shielding Recommendations. As mentioned in §2-6A, the preliminary zero adjustment is required when the instrument is to be used on the three most sensitive ranges or when first setting up. Difficulty may be experienced in zeroing if the instrument is subjected to strong noise fields (as noted in §2-4F), making it necessary to shield the input to the power sensor for this adjustment.

The simplest method of shielding the sensor (for zeroing) is to connect it to the device being used, making sure that the device is first turned off. Occasionally, however, the device itself will act as an antenna and actually introduce the noise voltage into the sensor. Should this be the case, stand the sensor vertically on a copper plate, holding it down firmly so that the rim of the connector body is in good contact with the copper at all points, then proceed with the zeroing operation. An alternative method is to wrap a piece of thin copper foil around the barrel of the sensor, and crimp or fold it around the open end of the connector. (Do not "short" the center pin, however.) If frequent zeroing in strong noise fields is necessary, construct an adapter, using a Type N connector permanently fitted with a copper-foil shield.

H. Over- and Under-Range Indication. When the power applied to the sensor is approximately 5% above the maximum of the range in use, or 12% below the minimum, the digital display will blank out. An arrow indicator will then appear, pointing upward or downward, to show the direction of the required range change. In instruments with the autoranging option installed, this range switching will be automatically controlled by the indicator circuits when the instrument is in the autorange mode.

I. Analog output. The d.c. output voltage at the RECORDER terminals on the rear panel is directly proportional to the power level at the sensor's input. It is positive with respect to chassis ground, with a maximum value of 10 volts at full scale on all ranges. The voltage is linear with respect to power down to about 10% of full scale (the point where the digital display blanks out). Linearity is not specified below this point, and the operator should switch the 42BD to the next lower range. (See Figure 2-5.) Terminal 20 on the rear card-edge connector is at logic 1 (about 4 volts) when the applied signal goes below range and the indicator blanks out. Connection 21 operates in similar fashion for overrange indication. If desired, these outputs can be used to operate an external warning device in order to alert the operator to the fact that the d.c. output has entered an unreliable region.

J. BCD Output. Serialized binary-coded-decimal output (4-line, 8-4-2-1) is available at the rear card-edge connector, together with BCD command inputs. Output information includes range, digits, overrange, and underrange indications, mode, and "encode complete." Logic 0 is < 0.7 V, and Logic 1 is 2.4 to 5.25 V.

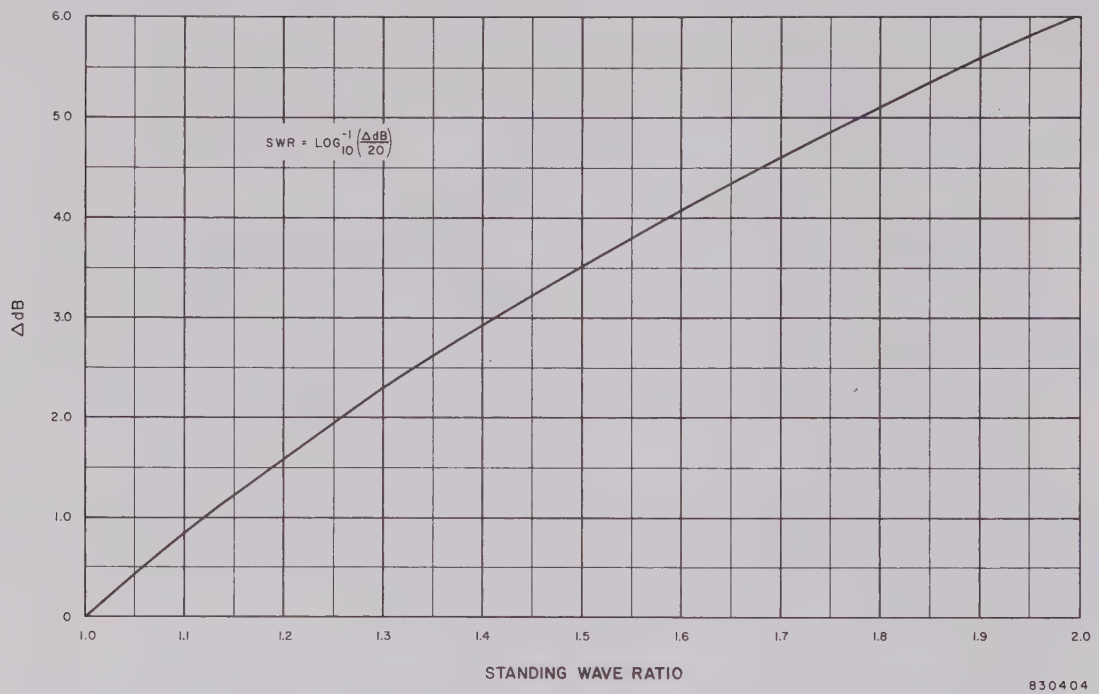


Figure 2-4. Conversion Chart: ΔdB vs S.W.R.

K. Programming. Logic-level inputs to the appropriate pins on the rear card-edge connector select ranges and modes, encode hold, encode trigger, and manual disable. Logic levels are standard TTL inputs; logic 0 enables a function, while logic 1 disables it. See §2-7 for detailed information.

L. Autoranging (Option -01). The 42BD can be operated in the automatic ranging mode by pressing the AUTO pushbutton, or by grounding the proper pin on the rear card-edge connector. With this option installed, the range is automatically switched up or down as the applied power reaches triggering points slightly above or below the calibrated range. These points are adjusted at the factory to ensure adequate overlap between adjacent ranges. When the 42BD-01 forms part of an external test system, a logic 0 to pin 6 (Auto Enable) and pin 7 (Manual Disable) will place the 42BD in Autorange.

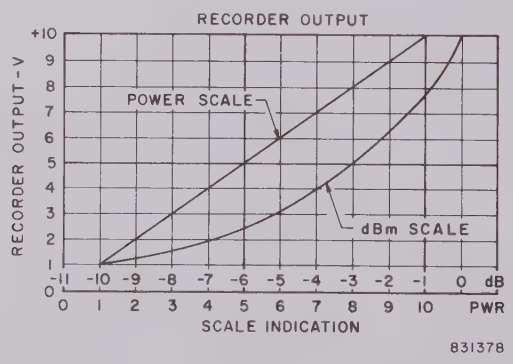


Figure 2-5. D.C. Output Correction Curves

M. dBm - Power Readout (Option -09). With Option -09 installed, the readout can be switched to indicate either power or dBm. The switching can be done either manually or by logic-level command inputs.

N. Buffered Serial-to-Parallel Converter (Option -21). This option, which connects to the rear card-edge connector, converts the normal serialized BCD outputs to a parallel format.

2.7 INTERFACE OPERATION

Remote programming is accomplished by simultaneously shorting to common the Manual Disable and the appropriate range lines on the card-edge connector located at the rear of the 42BD. When the Manual Disable is brought to common (i.e., pin 5), the front-panel switches in effect are disconnected. Figure 2-4 is a pictorial diagram of the rear-panel programming inputs and data output connections. Tables 2-2 through 2-5 provide additional data on these connections.

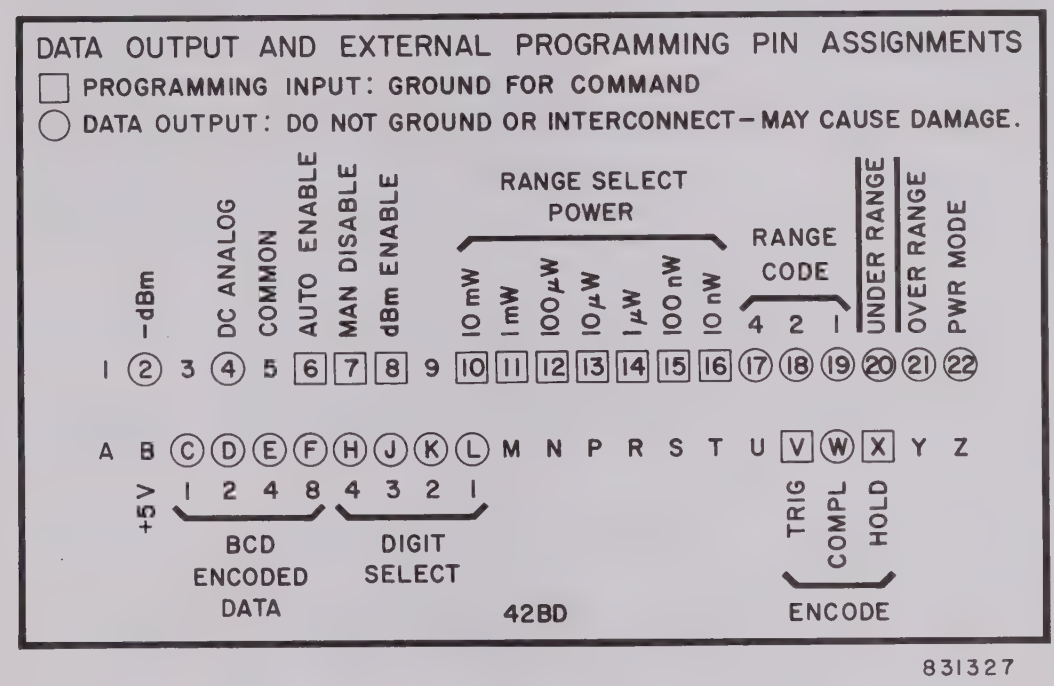


Figure 2-6. Rear-Panel Pin Assignments, 42BD

NOTE: The 42CD differs only in that pins 10 through 16 are for power ranges ten times higher than those shown (pin 10 = 100 mW, pin 16 = 100 nW, etc.).

A. Programming Inputs.

Table 2-2. Rear-Panel Pins: Programming Inputs

Pin No.	Function	Comment	Command	Unit Loading
7	Man.Disable	Disables front-panel range selection	0	0.1
8	dBm Enable	Selects dBm display*	0	0.1
6	Auto Enable	Selects automatic ranging* *With Manual Disable also selected	0	0.1
16	10 [100] nW	Selects range, provided that Manual	0	0.1
15	100 nW [1µW]	Disable has also been selected.	0	0.1
14	1 [10] µW	Selecting more than one range will	0	0.1
13	10 [100] µW	result in incorrect indications.	0	0.1
12	100 µW [1mW]	Range lines must be de-selected for	0	0.1
11	1 [10] mW	manual operation.	0	0.1
10	10 [100] mW		0	0.1
X	Encode Hold	Holds display	0	0.2
V	Encode Trigger	Starts "encode" cycle	see §2-7D	0.1

B. Input Characteristics. Interface input characteristics are given in Table 2-3.

Table 2-3. Interface Input Characteristics

TTL Series	Logic Level	Voltage Level	Current per Unit Load
Standard Power 54/74	0	≤ 0.7 V	-1.6 mA*
	1	2.4 to 5.25 V	40 µA

*The "-" current indicates current out of the input (the external command device must sink this current). A standard power (Series 54/74) TTL output will sink and source 10 unit loads.

C. Input Pull-Up. All input terminals have internal pull-up. The current sourced by this pull-up when the input is brought to a logic-level 0 is included in the loading shown in the "Unit Loading" column of Table 2-3.

D. Triggering. To trigger an "encode" cycle, the trigger line must be transferred from logic "1" to logic "0". The limits for trigger-pulse characteristics are shown in Figure 2-7.

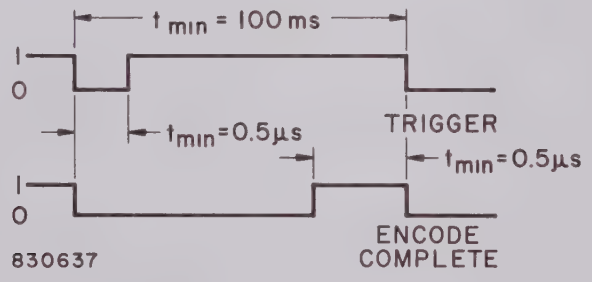


Figure 2-7. Encode-Trigger Timing Graph

E. Output Characteristics. Interface output characteristics are given in Table 2-4.

Table 2-4. Interface Output Characteristics

TTL Series	Logic Level	Voltage Level	Current per Unit Load
Standard Power 54/74	0	≤ 0.7 V	1.6 mA
	1	2.4 to 5.25 V	-40 µA*

*The "-" current indicates current sourced by the output.

F. D.C. Analog Output.

1. Polarity: positive with respect to instrument ground. (The negative D.C. Analog Output terminal is at ground potential.)

2. Source Resistance: 9 kΩ.

§2-7, continued.

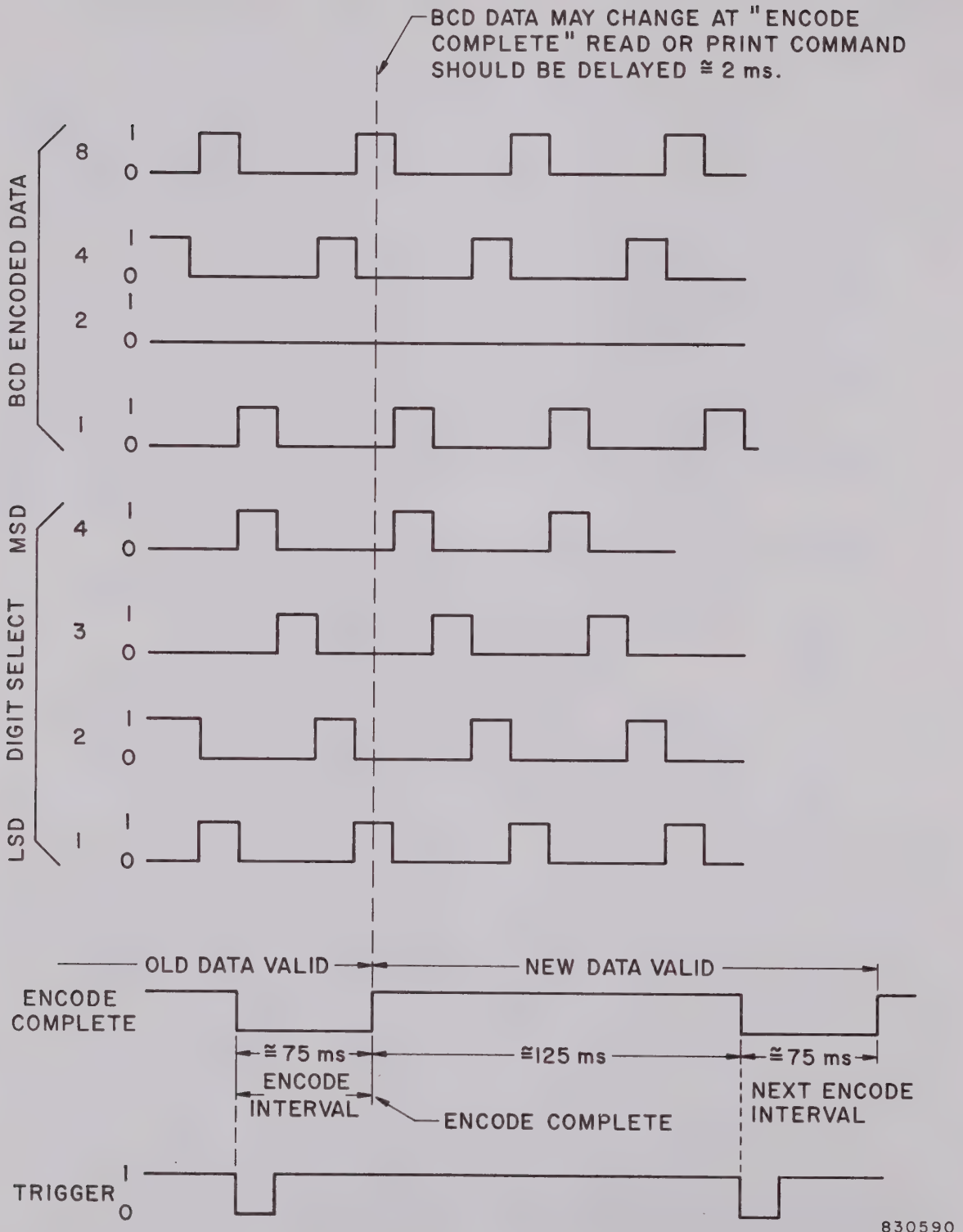
G. Data Outputs.

Table 2-5. Rear-Panel Pins: Data Outputs

Pin No.	Function	Comment	True-Logic Level	54/74 Unit Loading
22	mW mode	Indicates power display	1	1
4	D.C. Analog	10 V for full scale	N.A.	N.A.
21	Overrange	Indicates that 42BD's range should be increased	0	1
20	Underrange	Indicates that 42BD's range should be decreased	0	1
2	-dBm	Indicates that dBm is below the reference level	1	1
W	Encode Complete	Indicates completion of the encode cycle; data output may be read.	1	1
17	4	Indicates range selected, in binary code. 0 = 10 nW [100 nW] range 6 = 10 mW [100 mW] range	1	1
18	2 Range Code			
19	1			
F	8	Data in serial form, continulously scanned, left (MSD) to right, 500 µs per digit, 2 ms scan.	1	1
E	4 BCD		1	1
D	2 Encoded		1	1
C	1 Data		1	1
H	4	Indicates digit to which BCD data	1	1
J	3 Digit	applies. 4 = MSD (left-most)	1	1
K	2 Select		1	1
L	1		1	1

H. Autoranging Characteristics. The 42BD up-ranges at approximately 107% of full scale; it down-ranges at approximately 28% of full scale.

I. Data Output Timing. See Figure 2-8, below.



NOTE:
BCD DATA INDICATED: "1048"

Figure 2-8. Data-Output Timing Graph

SECTION III

THEORY OF OPERATION

3-1. INTRODUCTION

For this discussion, refer to Figure 3-1, a block diagram of the 42BD. The essential elements of the instrument are: sensor, chopper, pulse generator, demodulator, shaping amplifier, digital control, analog-to-digital (A-D) converter, digital display, panel meter, and power supply.

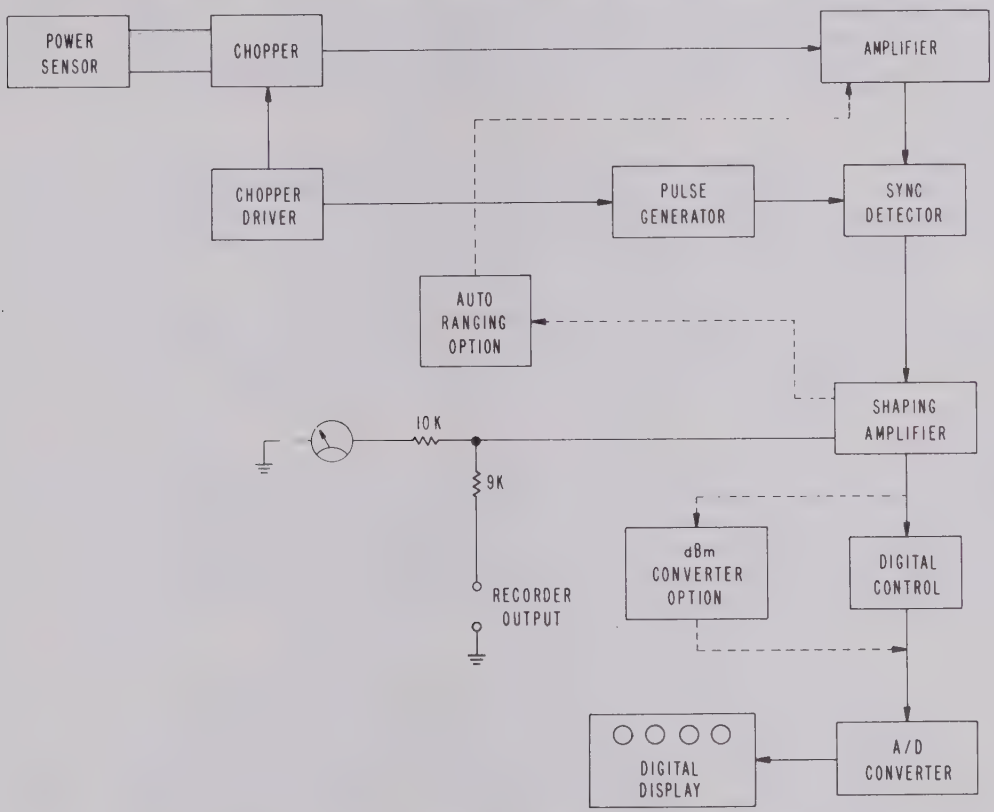


Figure 3-1. Model 42BD Block Diagram

3-2. POWER SENSOR

The Power Sensor contains a non-inductive load resistor of 50 Ω (75 Ω in the 4-14C sensor), and a pair of selected diodes connected as a full-wave rectifier across the resistor. The r.f. voltage appearing across the resistor is rectified by the diodes, producing a d.c. voltage whose level is a function of the power applied. When the applied power is within the square-law region of the diodes (below 20 µW [200 µW], average power), the detector shows true r.m.s. response. Above this power level the response approaches peak-to-peak, calibrated on the indicator is terms of r.m.s. power of a sine wave--thus providing accurate power measurements for c.w. and f.m. signals up to the maximum range of the sensor.

The use of full-wave rectification in the sensor permits the measurement of highly asymmetrical waveforms without substantial error. When a voltage of asymmetrical waveform is impressed on a single-diode rectifier circuit, whether or not the portion of the waveform that "turns on" the diode is restricted to the square-law region of the diode's characteristic, the recovered d.c. voltage is dependent upon the phase of the input voltage.

§3-2, continued.

Consider a positive pulse of low duty cycle applied to the anode of a diode rectifier. The rectified d.c. voltage is a function of the polarity, amplitude, and duration of the pulse. If the pulse is inverted, it drives the diode into a reversed-bias condition and the recovered d.c. is sensibly zero. A full-wave rectifier circuit, on the other hand, yields an equal amount of d.c. irrespective of the polarity of the input pulse.

It is apparent that the average power in a pulse does not depend upon its phase. The response of a single diode (even when operating in its square-law region), cannot reflect that fact; a full-wave rectifier circuit does.

Special diodes are selected for use in sensors; they should not be replaced with off-the-shelf types. The considerations regarding repair of sensors are discussed in Section IV of this Instruction Manual.

3-3. CHOPPER

The chopper board contains four solid-state switches, which are used to convert input d.c. voltage to a 94 Hz square wave. The switches are controlled by 94-Hz chopper-drive signals supplied from a frequency-divider chain in the analog section. Potentiometers A4R4 and A4R5 provide means for adjusting the chopper so that it has zero output with zero input. Use of a solid-state chopper eliminates most of the undesirable characteristics of electro-mechanical choppers (for example: contact wear, bounce, and contamination). The output of the chopper is a balanced 94 Hz square wave that is directly proportional to the d.c. voltage applied from the sensor.

3-4. AMPLIFIER

The balanced 94 Hz square-wave signal from the chopper is amplified by the operational amplifiers A2U3, A2U4, A2U6 and A2U8. The gain of the op amps A2U3, A2U4 and A2U6 is controlled by adjusting feedback to the amplifier through the multiplexer A2U2 and a resistor network. The signals from the ranging section, applied through gates A2U7a and A2U7b, control the switching of input terminals D1 and D2 of multiplexer A2U2 to two of eight points in the resistance networks, thereby adjusting the feedback and the gain of the amplifier.

The 94 Hz output of op amps A2U3 and A2U4 is applied to the differential inputs of op amp A2U6, which makes the signal single-ended. This signal is amplified by op amp A2U8 and associated circuitry. Multiplexer A2U9 adjusts the gain of this op amp in eight steps, under control of signals from the ranging section, to provided decade ranging in voltage. The nominal output for a full-scale input on each range is about four volts, p-p (at TP2). Separate potentiometers are provided for full-scale calibration of the instrument on each range.

3-5. DEMODULATOR

A solid-state demodulator, comprising switches A2U11b and A2U11c, converts the amplified and scaled 94 Hz square-wave signal back to d.c. The demodulator is driven by a 94 Hz demodulator-drive signal, which is synchronized with the 94 Hz chopper-drive signal. A synchronous, sampling demodulator circuit is used, with the sample being taken at a point well removed from the chopper-switching points. The demodulator is followed by the high-input-impedance buffer A2U17 to reduce loading of the sampling capacitor, A2C10, to negligible proportions. Output d.c. is supplied to the shaping section.

3-6. SHAPING AMPLIFIER

The conversion of r.f. to d.c. in the probe is nonlinear: the response is square-law for the lower ranges, gradually becoming quasi-linear for the 10 mW [100 mW] range. The shaping amplifier converts the nonlinear output of the phase detector (§3-5) to a linear output by using a segmental approximation to the exact correction. The shaping amplifier is an operational amplifier so connected that, as the signal increases at its output, its gain is reduced by successively paralleling resistors across the feedback resistors. The number of segments required to linearize the response adequately varies from zero for the square-law range up to six for the 10 mW

[100 mW] range. The output of the shaping amplifier at full scale is +10 V; this voltage is applied to the miniature panel meter, the RECORDER terminals though a 9 kΩ resistor, and to the digital control circuits.

3-7. DIGITAL CONTROL

The analog d.c. signal voltage from the shaping amplifier is processed by the digital control circuits before being passed on to the A-D converter and the digital display. The digital control section divides the incoming voltage (10 V, f.s.) by a factors of 20. It extracts information for the control of range, decimal-point position, over- or under-range indications, polarity indication and mode indications. In instruments with option -09, this section also contains the additional circuitry to convert the incoming power information into dBm values. The processed analog signal is then passed on the A-D converter section.

3-8. ANALOG-DIGITAL CONVERTER

In this dual-slope converter, incoming analog information is changed into digital form and applied to the digital-display unit, where the appropriate segments of the LED display are triggered. In addition to numerals, the display shows over- and under-range indicators, polarity, and units (nW, µW, mW, dBm).

3-9. POWER SUPPLY

The power supply converts the a.c. input power to regulated +15 and -15 V outputs. Each supply is protected by current limiting against accidental short circuits. Both supplies are adjustable to 15.0 ± 0.1 V.

3-10. PROGRAMMING

The 42BD is organized around an 8-line ranging system (i.e.: seven ranges and AUTO). Switching, in each functional sub-circuit, is accomplished by solid-state devices that are actuated by grounding the appropriate range line. The front-panel range switch simply connects to the eight range lines to allow range selection. The range lines are buffered by a logic-level converter. The 42BD can be externally ranged by a logic "0" command on the appropriate range line and the manual-disable line.

SECTION IV

MAINTENANCE

4-1. PERIODIC CALIBRATION

The 42BD is designed to be trouble-free over extended periods of time. However, as with any precision instrument, it should have its performance checked periodically to ensure that the specified accuracy is maintained. This Section contains operation checks, procedures for calibration of the instrument, and troubleshooting. It is well to remember, when working with an instrument with the sensitivity and bandwidth of the 42BD, that all precautions against stray pickup should be taken.

4-2. OPERATION CHECKS

Because of the excellent low-frequency response of the 42BD, it is convenient to check the calibration by using power sources in the frequency range of 200 kHz to 1 Mhz. To make such calibration checks, The Boonton Model 25A Power Meter Calibrator is suggested. It provides a 1 MHz crystal-controlled output at the correct signal levels required to check full-scale and incremental values on all ranges of the Model 42BD. If a Model 25A is not available, follow the procedure given below using the suggested equipment or equivalents.

A. All Ranges Except 10 mW [Except 10 and 100 mW].

1. Suggested Equipment (if a Model 25A is not available):

D.C. Source	H-P 6218A
A.C. Source	H-P 209A
Micropotentiometer	Ballentine Model 440 with 5 mA and 15 mA thermocouples, and radial resistors of 150 mΩ, 1.5 Ω, and 15 Ω.
D.C. Meter #1 (Digital Voltmeter)	H-P 3466A (pad for Z_{in} = 50 Ω)
D.C. Meter #2 (D.C. Null Volt-Ammeter)	H-P 419A

Refer to Figure 4-1 for the interconnection of test equipment.

2. Procedure:
Each range is checked by connecting the appropriate micropotentiometer (thermocouple and radial resistor) to the d.c. source and d.c. meter #1, then adjusting the source until d.c. meter #1 reads the voltage equivalent to full-scale power for that range. (See Table 4-1.) The reading of the d.c. meter #2 is then recorded.

Connect the micropotentiometer to the a.c. source and to the 42BD under test. Adjust the a.c. source until d.c. meter # 2 indicates the same value as that recorded above. The r.m.s. output voltage of the micropotentiometer is now equivalent to the d.c. voltage previously read on the d.c. meter #1. The 42BD should now read full-scale, within the tolerances given in the Specifications.

If the -09 Option is installed, full-scale dBm readings can be checked, although this procedure is not normally required. A range should be checked first in the PWR mode. The input should then be adjusted, if necessary, to yield an exact full-scale PWR reading on the 42BD. Now set the 42BD to the dBm mode to check the correspondence of the dBm and PWR readings before moving on to the next PWR range check.

Table 4-1. Test Levels

Model 42BD F.S. Range	Model 440: Thermocouple and Resistor	Voltage to Model 42BD Equivalent to D.C. Meter #1
10 nW*†	5 mA 150 mΩ	0.707 mV
100 nW†	15 mA 150 mΩ	2.236 mV
1 μW†	5 mA 1.5 Ω	7.071 mV
10 μW	15 mA 1.5 Ω	22.36 mV
100 mW	5 mA 15 Ω	70.71 mV
1 mW	15 mA 15 Ω	223.6 mV

* 42BD only.
† Preliminary zero-adjustment required.

B. 10 mW Range.

1. Suggested Equipment (if a Model 25A is not available):

D.C. Source	H-P 6218A
A.C. Source	H-P 209A
D.C. Meter #1 (Digital Voltmeter)	H-P 3466A
D.C. Meter #2 (D.C. Null Volt-Ammeter)	H-P 419A
Thermal Voltage Converter (TVC)	Ballantine 1393-1
Frequency Counter	Data Precision 585

Refer to Figure 4-2 for the interconnection of test equipment.

2. Procedure:

The 10 mW range is checked by connecting the TVC to the d.c. source. The d.c. source is adjusted until d.c. meter #1 reads 707 mV. The reading of meter #2 is now recorded.

Connect the TVC to the a.c. source tee. Adjust the a.c. source until d.c. meter #2 reads the same value as that recorded above. The r.m.s. voltage now connected to the 42BD will have a value equivalent to the 707 mV reading of d.c. meter #1.

The 42BD should now read full-scale, within the tolerances given in the Specifications section. If the -09 Option is installed, make this check first in the PWR mode, then in the dBm mode. See §4-2A2.

C. 100 mW Range (42CD only). Suggested Equipment, interconnection, and Procedure as in (B), above, except that the 707 mV referred to twice in the Procedure should be changed to 2.236 V.

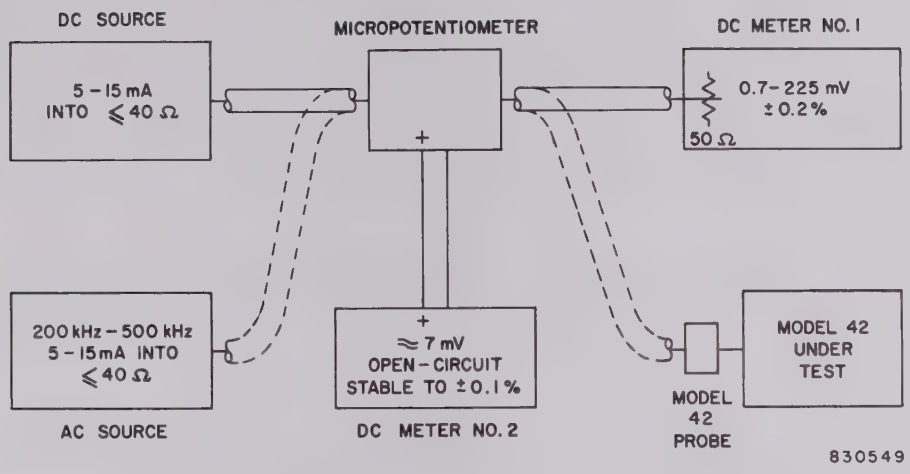
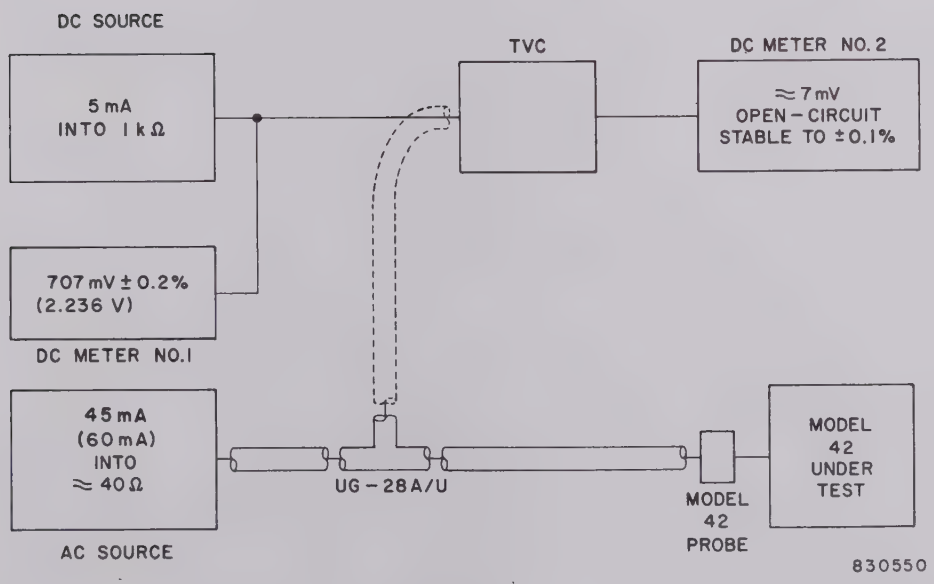


Figure 4-1. First Test Setup



NOTE:
( ) 100mW CALIBRATION LEVEL

Figure 4-2. Second Test Setup

§4-2, continued.

This completes the operation checks. If any ranges are out of specified tolerance, the calibration procedures of §4-4 should be performed.

4-3. CALIBRATION REQUIREMENTS

A. General.

1. The 42BD should be calibrated at an ambient temperature of 20° to 22°C (68° to 72°F) after a warm-up period of one hour.

2. Refer to Figure 4-3 for the location of PC boards and test points.

3. Be sure that the CAL FACTOR control is set at 0 (zero). If the control knob has been removed from its shaft, perform adjustment #27 first.

B. Test Instruments. A Model 25A Power Meter Calibrator is recommended as the signal source in these calibrations. Calibration adjustments that call for the application of specified input power levels then require only that the appropriate button be depressed on the 25A.

The following instruments are also needed:

1. A digital d.c. voltmeter (DVM), capable of measuring ± 15.00 V, accurate to 0.1% or better, with input impedance ≥ 10 MΩ.

2. An oscilloscope.

3. If a 75 Ω power sensor is being used with the 42BD, a 50 Ω to 75 Ω transformer (type N, female to female connectors) will be required between the 25A and the power sensor.

As an aid in the event that a Model 25A is not available, adjustments that call for the application of specified input power levels are followed in parentheses by input voltage levels that will produce the required power across the 50 Ω sensor. Voltage levels marked with asterisks should be used for 75 Ω power sensors. The following auxiliary instruments also will be required if a Model 25A is not avaliable:

4. A reliable signal source of 200 kHz - 500 kHz with less than 1% distortion at levels up to 3 volts across 50 ohms.

5. A precision a.c.v.m. such as the Ballantine 310A or 300H, Boonton Model 93A or 93AD, the Hewlett-Packard 400D or 400H, or equivalent.

4-4. CALIBRATION PROCEDURE

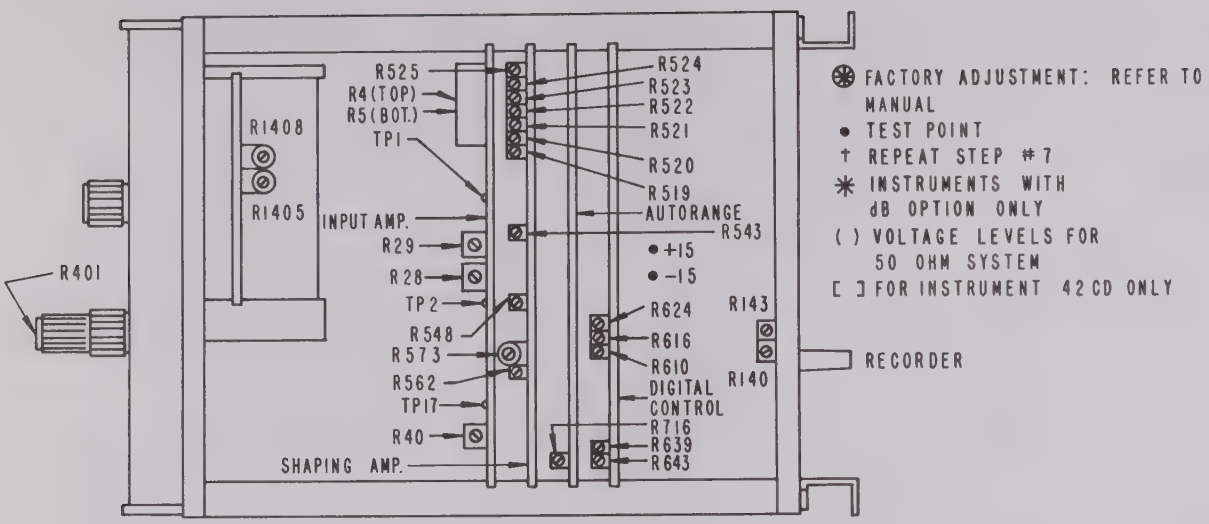
Adjustment No. 1. Measure the -15.0 V supply voltage at the -15 V Test Point located on the Main Amplifier Board at C119. Adjust R143 for a reading of -15.0 ± 0.1 V.

Adjustment No. 2. Measure the +15 V supply voltage at the +15 V Test Point located on the Main Amplifier board at C118. Adjust R140 for a reading of +15.0 ± 0.1 V.

Adjustment #3. Depress the 1 µW [10 µW] FULL SCALE range pushbutton. Connect DVM to TP2. With no input to the sensor, adjust R28 for 0.00 V d.c. on the DVM.

Adjustment #4. With zero input to sensor, connect DVM to TP17. Adjust R40 for 0.00 V d.c. on the DVM.

Adjustment #5. Depress the 10 nW [100 nW] FULL SCALE range pushbutton. Connect DVM to TP17 and note the indication (again, with zero input to the sensor). Set the two chopper adjustments, R4 and R5, to their physical midpoints. Adjust R4 to decrease the voltmeter's indication to one-half



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ADJ NO	CONT	FUNCTION	RANGE	INPUT PWR ±0.2% (50 OHMS)	ADJUST
1	R143	-15V ADJ	-	0	-15.0V ±0.1V AT -15V TP
2	R140	+15V ADJ	-	0	+15.0V ±0.1V AT +15V TP
3	R28	DC ZERO	1 μW [10 μW]	0	0.00V ±0.01V AT TP2
4	R40	DETECTOR ZERO	1 μW [10 μW]	0	0.00V ±0.1V AT TP17
5	R4 1/2 & R5 1/2	CHOPPER ZERO	10 nW [100 nW]	0	AVERAGE ZERO INDICATION AT TP17
6	R40	RECORDER ZERO	1 μW [10 μW]	0	0.00V ±0.01V AT RECORDER TERMINALS
7	R401	FRONT PANEL ZERO	10 nW [100 nW]	0	AVERAGE ZERO INDICATION AT RECORDER TERMINALS
8	R29	OVERALL GAIN	1 μW [10 μW]	1 μW (7.071 mV) [10 μW (22.36 mV)]	-3.00V AT TP17
9†	R523	FS RANGE ADJ	1 μW [10 μW]	1 μW (7.071 mV) [10 μW (22.36 mV)]	+10.00V AT RECORDER TERMINALS DC VOLTMETER INPUT > 10 MEGOHMS
10	R643	FS DIVIDER	1 μW [10 μW]	1 μW (7.071 mV) [10 μW (22.36 mV)]	0.500V AT PIN 8 OF IC605
11	R1405	+DPM FS ADJ	1 μW [10 μW]	1 μW (7.071 mV) [10 μW (22.36 mV)]	1.000 μW [10.00 μW] INDICATION
12	R639	EDGEMETER ADJ	1 μW [10 μW]	1 μW (7.071 mV) [10 μW (22.36 mV)]	ZERO dBm INDICATION
13	R716	AUTORANGE TRIP ADJ	AUTO	1-1.1 μW [10-11 μW]	TRIP TO 10 [100] μW RANGE AT 1.03 [10.3] μW
14†	R525	FS RANGE ADJ	10 nW [100 nW]	10 nW (0.707 mV) [100 nW (2.236 mV)]	10.00 nW [100.0 nW] INDICATION
15†	R524	FS RANGE ADJ	100 nW [1 μW]	100 nW (2.236 mV) [1 μW (7.071 mV)]	100 nW [1.000 μW] INDICATION
16	R522	FS RANGE ADJ	10 μW [100 μW]	10 μW (22.36 mV) [100 μW (70.71 mV)]	10.00 μW [100.0 μW] INDICATION
17	R521	FS RANGE ADJ	100 μW [1 mW]	100 μW (70.71 mV) [1 mW (223.6 mV)]	100.0 μW [1.000 mW] INDICATION
18	R543	DS ADJ	100 μW [1 mW]	10 μW (22.36 mV) [100 μW (70.71 mV)]	10.0 μW [0.100 mW] INDICATION
19	R520	FS RANGE ADJ	1 mW [10 mW]	1 mW (223.6 mV) [10 mW (707.1 mV)]	1.000 mW [10.00 mW] INDICATION
20	R548	DS ADJ	1 mW [10 mW]	100 μW (70.71 mV) [1 mW (223.6 mV)]	0.100 mW [1.00 mW] INDICATION
21	R519	FS RANGE ADJ	10 mW [100 mW]	10 mW (707.1 mV) [100 mW (2236 mV)]	10.00 mW [100.0 mW] INDICATION
22	R562	DS ADJ	10 mW [100 mW]	1 mW (223.6 mV) [10 mW (707.1 mV)]	1.00 mW [10.0 mW] INDICATION
23	R1408	-DPM FS ADJ ✳	1 mW [10 mW]	-6.00 VDC	-60.00 [-60.00] dB INDICATION
24	R610	dB REFERENCE	+10 dBm [+20 dBm]	+10.00 VDC	+10.00 [+20.00] dB INDICATION
25	R624	dB RANGING ✳	-50 dBm [-40 dBm]	+10.00 VDC	60 dB SPREAD, BETWEEN +10 [+20] AND -50 [-40] dBm
26	R616	dB LINEARITY	+10 dBm [+10 dBm]	1-10 VDC	10 dB SPREAD, BETWEEN 0 [+10] AND -10 [0] dBm
27	R573	CAL. FACTOR ADJ	⊛	READJUST IF CAL. FACTOR KNOB IS REMOVED FROM SHAFT.	

Figure 4-3. Location of PC Boards and Test Points

of the value noted above. Adjust R5 to bring the indication to zero. There will be some fluctuation of the indication, and averaging will be required.

Adjustment #6. Depress the 1 µW [10 µW] FULL SCALE range pushbutton, with zero input to the sensor. Connect the DVM to the RECORDER terminals on the rear panel of the 42BD. Adjust R40 for 0.00 V d.c. on the DVM.

Adjustment #7. Depress the 10 nW [100 nW] FULL SCALE range pushbutton (with zero input to the sensor), and zero the 42BD as described in §2-4F.

Adjustment #8. Depress the 1 µW [10 µW] FULL SCALE range pushbutton. Connect the DVM to TP17. Apply 1 µW (7.071 mV, 8.660 mV*) [10 µW (22.36 mV)] to the sensor. Adjust R29 for a reading of -3.00 V d.c. on the DVM.

Adjustment #9. Depress the 1 µW [10 µW] FULL SCALE range pushbutton. Apply 1 µW (7.071 mV, 8.660 mV*) [10 µW (22.36 mV)] to the sensor. Measure the voltage at the RECORDER terminals on the rear panel; it should be 10.00 volts. If necessary, adjust R523 on the shaping amplifier board to obtain the required voltage.

Adjustment #10. Depress the 1 µW [10 µW] FULL SCALE range pushbutton. Apply 1 µW (7.071 mV, 8.660 mV*) [10 µW (22.36 mV)] to the sensor. The display indication should be 1.000 µW [10.00 µW]. If it is not, adjust R643 for 0.5000 V, d.c., at pin 8 of IC605; then do Adjustment 11.

Adjustment #11. Adjust R1405 on the analog-digital converter board for a display indication of 1.000 µW.

Adjustment #12. Depress the 1 µW [10 µW] FULL SCALE range pushbutton. Apply 1 µW (7.071 mV, 8.660 mV*) [10 µW (22.36 mV)] to the sensor. The panel edgemeter should read 0 dB. If necessary, adjust R639 on the digital control board to obtain the required reading.

Adjustment #13, for instruments with Autorange option. NOTE: Normally this adjustment is not required.

This adjustment requires a continuously variable r.f. level, which can best be obtained from a signal generator or oscillator. If necessary, a low-resistance potentiometer may be connected between the 25A Power Meter Calibrator and the power sensor. Absolute power levels and impedance matching are unimportant for these adjustments.

Depress the 1 µW [10 µW] FULL SCALE range pushbutton. Apply 1 µW (7.071 mV, 8.660 mV*) [10 µW (22.36 mV)] to the sensor. Depress the AUTO button of the FULL SCALE range selector, and increase the input level slowly--noting the point at which the 42BD changes up to the 10 µW [100 µW] range. Refer to §2-6H for overrange and underrange indications. The range switching should occur when the display indication is 1.030 µW [10.30 µW]. If necessary, adjust R716 on the auto-range board for range switching at this display indication. Rotate R716 counterclockwise to decrease the trip-point level, or clockwise to increase the trip-point level. The adjustment may have to be repeated several times to reach the desired setting.

Adjustment #14. Depress the 10 nW [100 nW] FULL SCALE range pushbutton and zero the 42BD as described in §2-4F. Apply 10 nW (0.707 mV, 0.866 mV*) [100 nW (2.236 mV)] to the sensor. The display should indicate 10.00 nW [100.0 nW]. If necessary, adjust R525 on the shaping amplifier board to obtain the proper indication.

Adjustment #15. Depress the 100 nW [1 µW] FULL SCALE range pushbutton and zero the 42BD as described in §2-4F. Apply 100 nW (2.236 mV, 2.738 mV*) [1 µW (7.071 mV)] to the sensor. The display should indicate 100.0 nW [1.000 µW]. If necessary, adjust R524 on the shaping amplifier board to obtain the proper indication.

Adjustment #16. Depress the 10 µW [100 µW] FULL SCALE range pushbutton and apply 10 µW (22.36 mV, 27.38 mV*) [100 µW (70.71 mV)] to the sensor. The display should indicate 10.00 µW [100.0 µW]. If necessary, adjust R522 on the shaping amplifier board to obtain the proper indication.

Adjustment #17. Depress the 100 µW [1 mW] FULL SCALE range pushbutton and apply 100 µW (70.71 mV, 86.60 mV*) [1 mW (223.6 mV)] to the sensor. The display should indicate 100.0 µW [1.000 mW]. If necessary, adjust R521 on the shaping amplifier board to obtain the proper indication.

Adjustment #18. Depress the 100 µW [1 mW] FULL SCALE range pushbutton and apply 10 µW (22.36 mV, 27.38 mV*) [100 µW (70.71 mV)] to the sensor. The display should indicate 10.0 µW [0.100 mW]. If necessary, adjust R543 on the shaping amplifier board to obtain the proper indication.

Adjustment #19. Depress the 1 mW [10 mW] FULL SCALE range pushbutton and apply 1 mW (223.6 mV, 273.8 mV*) [10 mW (707.1 mV)] to the sensor. The display should indicate 1.000 mW [10.00 mW]. If necessary, adjust R520 on the shaping amplifier board to obtain the proper indication.

Adjustment #20. Depress the 1 mW [10 mW] FULL SCALE range pushbutton and apply 100 µW (70.71 mV, 86.60 mV*) [1 mW (223.6 mV)] to the sensor. The display should indicate 0.100 mW [1.000 mW]. If necessary, adjust R548 on the shaping amplifier board to obtain the proper indication.

Adjustment #21. Depress the 10 mW [100 mW] FULL SCALE range pushbutton and apply 10 mW (707.1 mV, 866.0 mV*) [100 mW (2.236 V)] to the sensor. The display should indicate 10.00 mW [100.0 mW]. If necessary, adjust R519 on the shaping amplifier board to obtain the proper indication.

Adjustment #22. Depress the 10 mW [100 mW] FULL SCALE range pushbutton and apply 1 mW (223.6 mV, 273.8 mV*) [10 mW (707.1 mV)] to the sensor. The display should indicate 1.00 mW [10.0 mW]. If necessary, adjust R562 on the shaping amplifier board to obtain the proper indication.

NOTE: Adjustments 23 through 26 apply only to instruments with dBm option.
Adjustment #23. Set the selector switch to OFF. Remove the digital control board and mask pins 1,2,Z, and 22 with tape. Insert the control board in the extender board, then insert the latter in the 42BD. Depress the 1 mW [10 mW] FULL SCALE range pushbutton and set the selector switch to dBm. Apply -6.000 V, d.c., ±0.1%, at the junction of R628 and R625. If necessary, adjust R1408 on the digital panel meter board for a display of -60.00 dB [-60.00 dB]. Disconnect the input from the junction of R628 and R625.

Adjustment #24. Depress the +10 dBm [+20 dBm] FULL SCALE range pushbutton. Apply +10.00 V, d.c., ±0.1%, at the junction of R631 and R638. Adjust R610 for a display of +10.00 dB [+20.00 dB].

Adjustment #25. Depress the -50 dBm [-40 dBm] FULL SCALE range pushbutton and adjust R624 for a display of -50 dBm [-40 dBm]. There is some interaction in adjustments 24 and 25, so repeat them until both readings are as close as possible to the correct values. However, at this stage it is more important that the two readings show a 60 dB difference.

Check each range for the correct reading in dBm, ± 0.1 dB. Touch up R624 to bring in the middle ranges if they are out by more than ±0.2 dB.

Adjustment #26. Depress the 0 dBm [+10 dBm] FULL SCALE range pushbutton and note the display. Reduce the applied d.c. from +10.00 to +1.000 V, ±0.1%, and again note the display. Adjust R616 for a 10 dB difference between the readings.

Remove the connection to the junction of R631 and R638. Turn the rotary selector switch to OFF. Remove the extender card, remove the tape from the digital control board, and re-insert the digital control board in the 42BD.

§4-4, continued.

Adjustment #27, Calibration-Factor Adjustment. NOTE: This adjustment will be required only if the CAL FACTOR knob has been removed from its shaft, of if slippage of the knob on the shaft is suspected.

This adjustment requires a continuously variable r.f. level, which can best be obtained from a signal generator or oscillator. If necessary, a low-resistance potentiometer may be connected between the 25A Power Meter Calibrator and the power sensor. Absolute power levels and impedance matching are unimportant for these adjustments.

Center the CAL FACTOR knob on the shaft so that the pointer swings an equal amount past the end points on each end of the rotation. Depress the 1 μW [10 μW] FULL SCALE range pushbutton. Set the CAL FACTOR control to -1 dB. Apply an a.c. signal to the sensor and adjust its level so that a display of 0.631 μW, or -32 dBm [6.31 μW, or -22 dBm] is obtained. Rotate the CAL FACTOR control to the +1 dB position and adjust R573 on the shaping amplifier board for a display of 1.000 μW, or -30.00 dBm [10.00 μW, or -20 dBm].

Adjustment #28. NOTE: This adjustment is required only in the event that IC1202 is replaced, and a 50 ms pulse is not obtained at pin 8 of IC1402.

Using an oscilloscope, measure the pulse width at pin 8 of IC1402. The pulse should be 50 ms wide. If necessary, adjust C1203 to obtain the proper pulse width. If this value cannot be obtained within the range of C1203, try slightly different values of C1202 (up to 200 pF), until the 50 ms pulse is within the range of trimmer C1203.

4-5. TROUBLESHOOTING

If faulty operation of the 42BD is evident, or if the preceding calibration procedures fail to correct an inaccurate reading, reference to Table 4-2 will assist in identifying the cause of the trouble and determining the corrective action to be taken.

Often the nature of the difficulty itself will pinpoint the location of the trouble. If this is not the case, make a visual examination of the instrument by removing the top and bottom covers and inspecting for unseated printed-circuit boards or connectors, loose components or fasteners, obviously defective components such as charred resistors, leaking capacitors, broken leads, or for foreign material. If this inspection fails to locate the trouble, it is recommended that the sequential steps of procedure specified in Table 4-2 be followed, and that the schematic diagrams in Section VI of this Manual be referred to for assistance. It is recommended also that voltage measurements be made using a d.c. digital voltmeter of 0.1% accuracy or better. Use standard shop practices for isolating and replacing defective parts.

NOTE: Should it become necessary during troubleshooting to remove the CAL FACTOR control knob, first turn the control fully counterclockwise and mark the position of the knob pointer by a pencil scribe line on the front panel; then remove the knob. When replacing the knob, first align the pointer with the scribe mark, then secure the knob in position. Check Adjustment #27 after replacing the knob.

Table 4-2. Troubleshooting

STEP	TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
1	Inoperative Instrument	Faulty or incorrect line voltage.	Correct line voltage or repair connection.
2	"	Rear-panel slide switch in incorrect position for applied line voltage.	Set switch to proper position.
3	"	Defective or incorrect fuse.	Replace defective or incorrect fuse: 0.2 A for 115 V, 0.1 A for 230 V.
4	"	Defective Power Sensor.	Replace sensor and recalibrate instrument. NOTE: It is recommended that defective sensors be returned to the factory for repair. See §4-6.
5	"	Incorrect voltage at test point at C119 on amplifier board.	Adjust R143 to obtain -15.0 V ±0.1 V. If not attainable, check all components of -15 V supply. Replace defective parts.
6	"	Incorrect voltage at test point at C118 on amplifier board.	Adjust R140 to obtain +15.0 V ±0.1 V. If not attainable, check all components of +15 V supply. Replace defective parts.
7	Instrument Operative,but No Display	Incorrect voltage at test point between IC103 and IC106 on amplifier board.	Replace IC103 to obtain +5.0 V ±0.1 V. If voltage still not obtainable,check components of +5 V supply. Replace defective parts.
8	"	Defective or inoperative display lamps.	Replace defective lamps & check connections. Check all components of digital panel-meter display board; replace defective parts.
9	Instrument Operative,but Incorrect or Erratic Display	Defective or incorrect Power Sensor.	Make sure that the serial number of sensor is the same as that of the 42BD, or is one to which the 42BD has been calibrated. If sensor is defective, replace it & recalibrate the instrument. Refer to Step 4, above.

Table 4-2. Troubleshooting (Continued)

STEP	TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
10	Instrument Operative,but Incorrect or Erratic Display	Possible defective components and/or signal paths on PC boards: Digital Control; Display Panel-Meter A-D Converter; Digital Panel-Meter Counter Board; Digital Panel-Meter Display Board; Serial-Parallel BCD Converter; or, Shaping Amplifier.	A. Inject full-scale input on any range & read the RECORDER voltage at P105 (rear panel). Voltage should read +10 V. Lower input by a few dBm, check that RECORDER output follows input voltage. If RECORDER output does not follow input, go to B, below. If RECORDER output does follow input,proceed with these checks: Check waveshapes,voltages & resistances on these PC boards in the order given: Digital Control; Digital Panel-Meter A-D Converter, utilizing test points TP1 - TP7; Digital Panel-Meter Counter Board, utilizing TP1 - TP3; Digital Panel-Meter Display Board; and Serial-Parallel BCD Converter. If readings are incorrect, check all components in signal paths and feedback circuits. Replace defective parts, repair or replace defective interconnections. B. If RECORDER output does not follow input voltage, check waveshapes,voltages and resistances on the Shaping Amplifier board. If readings are incorrect, check all components in signal paths and feedback circuits. Replace defective parts, repair or replace defective interconnections. If this does not correct trouble, proceed with Step A, above.
11	Instrument Operative,but Display Does Not Blank Out When Input Power is Above or Below the Limits for the Selected Range.	Possible defective components and/or signal path on amplifier board and shaping amplifier.	Refer to Ranging Troubleshooting Chart, Figure 4-4.
12	Instrument Operative with Auto Switch Engaged, but Display Does Not Range Up or Down as Input Power is Varied.	Possible defective components and/or signal path on amplifier board.	Refer to Autoranging Troubleshooting Chart, Figure 4-5. NOTE: This procedure applies only to instruments equipped with Autoranging Option.

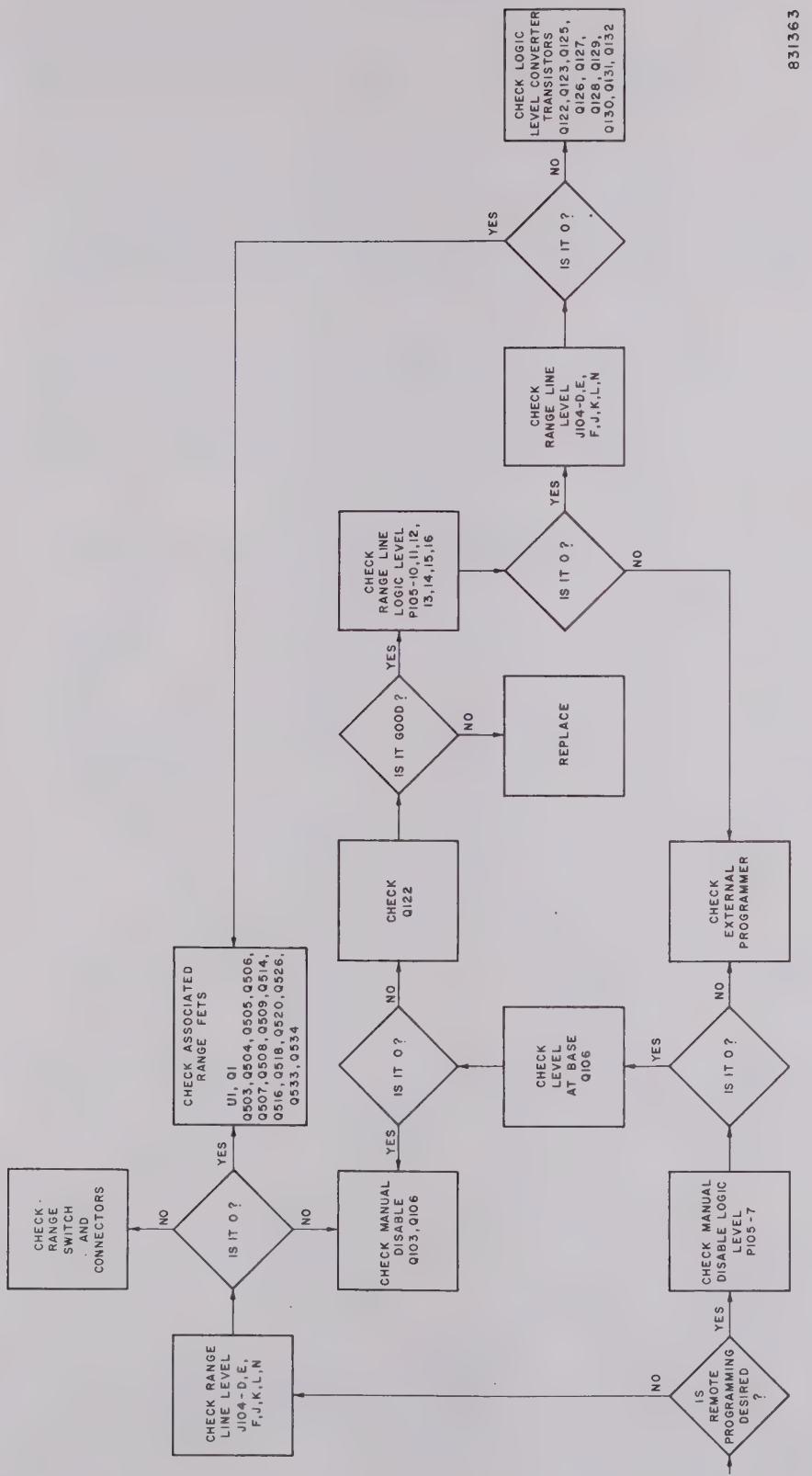

Figure 4-4. Ranging Troubleshooting Chart

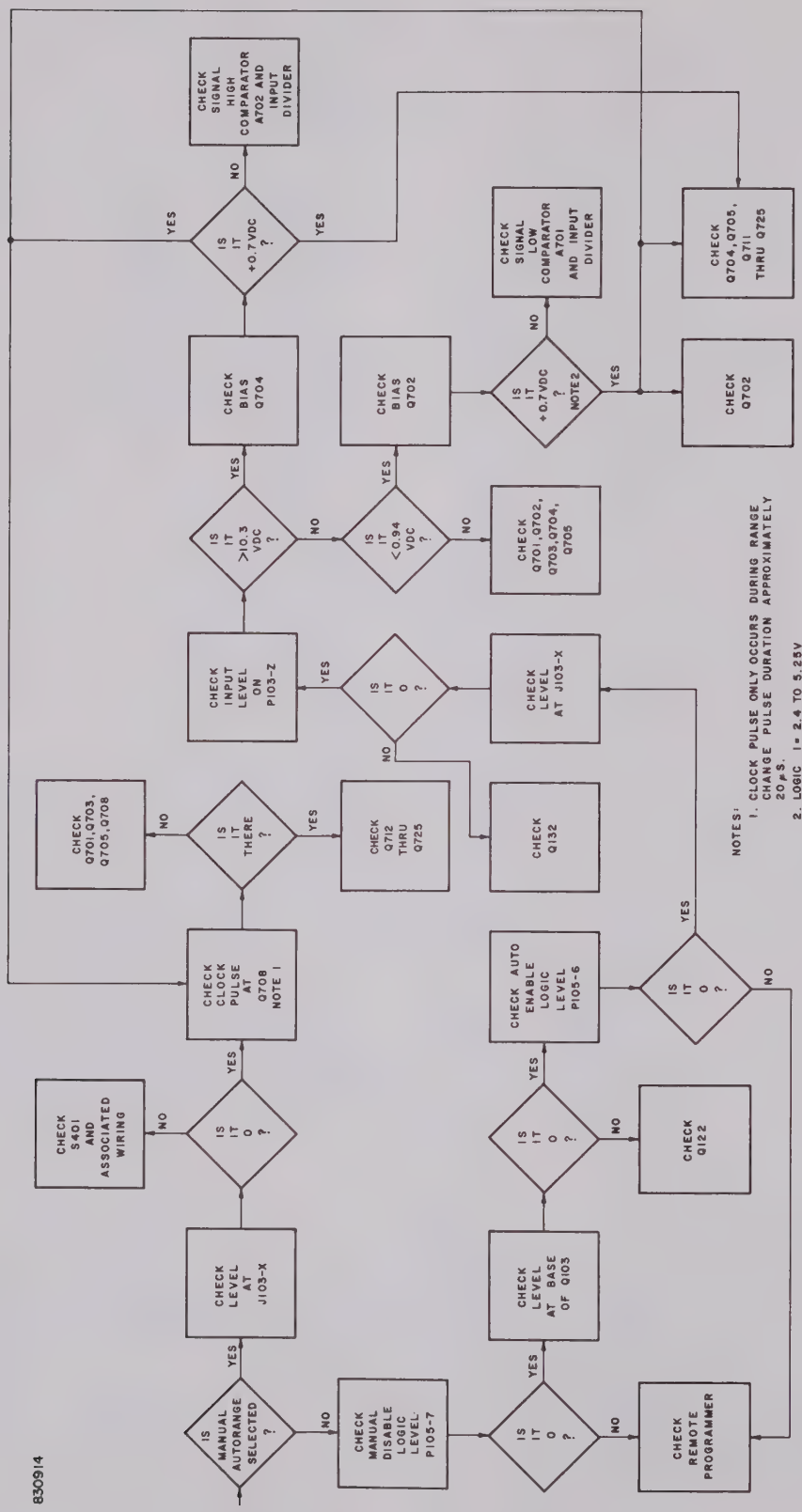
CHECK SIGNAL HIGH COMPARATOR A702 AND INPUT DIVIDER
IS IT +0.7 VDC ?
YES
NO
CHECK SIGNAL LOW COMPARATOR A701 AND INPUT DIVIDER
CHECK Q704, Q705, Q711 THRU Q725
CHECK BIAS Q704
CHECK BIAS Q702
IS IT +0.7 VDC ? NOTE 2
CHECK Q702
IS IT >10.3 VDC ?
IS IT <0.94 VDC ?
CHECK Q701, Q702, Q703, Q704, Q705
CHECK INPUT LEVEL ON P103-Z
IS IT 0 ?
CHECK LEVEL AT J103-X
CHECK Q701, Q703, Q705, Q708
IS IT THERE ?
CHECK Q712 THRU Q725
CHECK Q132
CHECK CLOCK PULSE AT Q708 NOTE 1
CHECK AUTO ENABLE LOGIC LEVEL P105-6
CHECK S401 AND ASSOCIATED WIRING
CHECK LEVEL AT J103-X
CHECK LEVEL AT BASE OF Q103
CHECK Q122
IS MANUAL AUTORANGE SELECTED ?
CHECK MANUAL DISABLE LOGIC LEVEL P105-7
CHECK REMOTE PROGRAMMER
NOTES:
1. CLOCK PULSE ONLY OCCURS DURING RANGE CHANGE PULSE DURATION APPROXIMATELY 20 μS.
2. LOGIC 1 = 2.4 TO 5.25V
LOGIC 0 = 0 TO ±0.7V
830914

Figure 4-5. Autoranging Troubleshooting Chart

4-6. POWER-SENSOR REPAIR

Repair and adjustment of a Power Sensor is a difficult operation, requiring a high degree of skill. It is strongly recommended that a defective sensor be returned to the Factory for repair.

If the user elects to make such a repair, he or she should consult with the Factory as to the recommended procedure; however, it must be understood that the repaired sensor may not meet the s.w.r. and response characteristics specified in this manual. For best results the repaired sensor should be recalibrated utilizing a specific procedure that requires special equipment. An application note entitled Determination of Calibration Factor is available at no charge from the Factory.

Before deciding that the sensor is defective, check all possible sources of troubles, such as the instrument itself, the sensor cable, connectors, the r.f. power source, and so forth. If the defect cannot be located, and the symptoms indicate a faulty sensor, make the external resistance measurements outlined below to localize the trouble before consulting with the Factory. (A volt-ohmeter such as the Simpson 260, or equivalent, is recommended for most of these measurements.)

A. Measure the resistance of the r.f. input connector from the center conductor to the ground shell. It should be 50 Ω, ± 1 Ω for all sensors but the 41-4C, in which case it should be 75 Ω, ± 1 Ω. (For this measurement, an instrument more accurate than the Simpson 260 should be used.)

B. Inspect the rear connector for possible damage. Measure the resistance from pins 1 and 2 to ground. They should measure > 10 MΩ.

C. With the VOM on its 10 kΩ range, measure the resistance from pin 1 (use the negative lead of the VOM) to pin 2 (positive lead of VOM). It should be 20 to 30 kΩ.

D. Reverse the connections of the VOM; it should now measure > 400 kΩ.

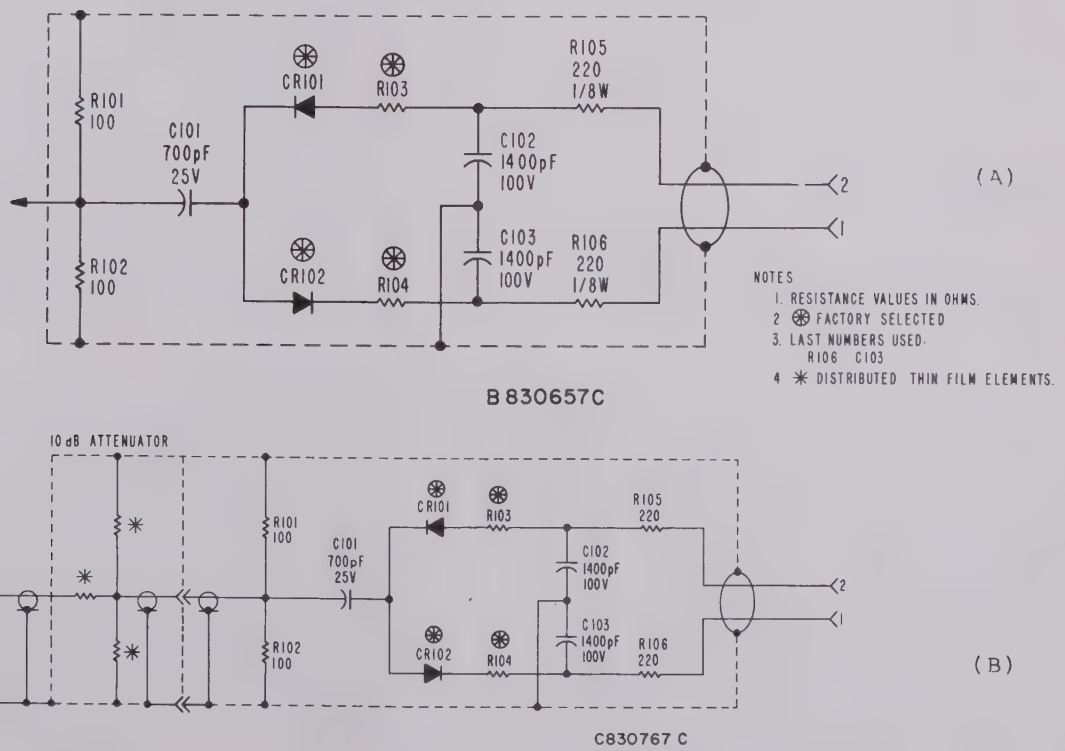

Figure 4-6. Typical Power Sensor: (A) for 42BD; (B) for 42CD

SECTION V

REPLACEABLE PARTS

5-1. INTRODUCTION

Table 5-2, Replaceable Parts, identifies the manufacturers of components by five-digit groups taken from the Federal Supply Code for Manufacturers. A list of the applicable code groups and manufacturers is given in Table 5-1.

The Table of Replaceable Parts begins with major assemblies, including PC boards complete with all their parts, followed by miscellaneous parts and components not mounted on PC boards. Then all the components of the individual assemblies (including PC boards) are listed. Note the following:

A. When ordering a component or an assembly, the BEC Part Number is all that we need. However, part numbers can suffer changes during transmission and it is safer to include also a brief description. Example:
BEC Part #200050: Mica Capacitor, 470 pF, 1%, 500V.

B. The number printed on a PC board is not an assembly number; it is the number for the bare board, alone. To order a complete assembly--the board with all its components installed--specify it by the BEC Part Number given in the Assemblies Section of this table.

C. Unless otherwise identified, the number on a schematic diagram or on a parts-location diagram is not an assembly number; it is the number for just the diagram itself.

Table 5-1. Applicable Federal Supply Code Numbers for Manufacturers

00241	Fenwal Electronics	32575	AMP
01121	Allen Bradley	32897	Erie
01139	General Electric	32997	Bourns, Inc., Trimpot Div.
01295	Texas Instruments	33883	RMC
02660	Amphenol	34430	Monsanto
02735	RCA Solid State Div.	50088	Mostek
04222	AVX Ceramics Company	54426	Buss Fuses
04713	Motorola Semiconductor	56289	Sprague Electric Company
04901	Boonton Electronics	57582	Kahgan Electronics Corp.
06776	Robinson Nugent, Inc.	59474	Jeffers Electronics, Inc.
07263	Fairchild Semiconductor	71450	CTS Corp.
08077	International Rectifier	73138	Beckman Instr., Helipot Div.
12697	Clarostat	81840	Ledex, Inc.
14655	Cornell-Dubilier	82389	Switchcraft
19701	Mepco Electra	84411	TRW Capacitors
20307	Arco - Micronics	91293	Johanson
27014	National Semiconductor	91506	Augat
27735	F-Dyne Electronics	91637	Dale Electronics
31313	Components Corp.	98291	Sealectro Corp.
32293	Intersil, Inc.	99942	Centralab (Globe Union)
		S4217	United Chemicon, Inc.

Table 5-2. Replaceable Parts

ASSEMBLIES	
Input Amplifier	Part Number 042140-00A
Input Resistor Networks	Part Numbers 042141-00A & 042142-00A
Master Board	Part Number 042129-00B
Shaping Amplifier	Part Number 042026-01N
Digital Control Board 42BD	Part Number 042050-01F
Digital Control Board 42CD	Part Number 042050-02F
Counter Board	Part Number 093006-00D
A-D Converter Board	Part Number 093007-01K
Display Board	Part Number 093008-01L
Switch Assembly	Part Number 042123-02B
Meter Assembly	Part Number 042125-01B
Chopper Assembly	Part Number 042161-01G
Rear-Panel Assembly	Part Number 042023-02B
Sub-Panel Assembly	Part Number 042024-02B
Harness Assembly	Part Number 042126-01C
Heat-Sink Assembly	Part Number 042144-00B

Table 5-2. Replaceable Parts

Replaceable Parts List for PWA Input Amplifier PL 042140-00A

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
C1	Capacitor EL 100 µF 20% 25V	S4217	SM-25-VB-100-M	283334-000
C2	Capacitor EL 100 µF 20% 25V	S4217	SM-25-VB-100-M	283334-000
C3	Capacitor Mylar 0.1 µF 10% 100V (only)	19701	C280MAH/A100K (only)	234080-000
C4	Capacitor Mica 1500 pF 1% 500V	14655	CD19-FD152F-03	200561-000
C5	Capacitor Mylar 0.1 µF 10% 100V (only)	19701	C280MAH/A100K (only)	234080-000
C6	Capacitor PE 0.022 µF 10% 80V	56289	192P2239R8	234096-000
C7	Capacitor PE 0.0022 µF 10% 200V	56289	192P22292	234110-000
C8	Capacitor EL 100 µF 20% 25V	S4217	SM-25-VB-100-M	283334-000
C9	Capacitor EL 100 µF 20% 25V	S4217	SM-25-VB-100-M	283334-000
C10	Capacitor PP 0.1 µF 10% 100V	27735	PP11-.1-100-10	234148-000
C11	Capacitor PC 470 nF 10% 50V	12406	B5A474K	234128-000
C12	Capacitor EL 10 µF 20% 25V	S4217	SM-25-VB-10-M	283336-000
C13	Capacitor EL 10 µF 20% 25V	S4217	SM-25-VB-10-M	283336-000
J1-1	Socket Pin Spring	32575	1-332070-7	479333-000
J1-2	Socket Pin Spring	32575	1-332070-7	479333-000
J1-3	Socket Pin Spring	32575	1-332070-7	479333-000
J1-4	Socket Pin Spring	32575	1-332070-7	479333-000
J1-5	Socket Pin Spring	32575	1-332070-7	479333-000
J1-6	Socket Pin Spring	32575	1-332070-7	479333-000
J1-7	Socket Pin Spring	32575	1-332070-7	479333-000
Q1	IC CA3096CE Transistor Array	02735	CA3096CE	535101-000
Q2	Transistor FET 2N5949 N-Channel	04713	2N5949	528019-000
R1	Resistor Network 10k ohm 2% SIP	71450	750-101-R10K	345038-000
R2	Resistor MF 47.5 ohm 1%	---	RN55D-47R5-F	341165-000
R3	Resistor MF 20.0k ohm 1%	---	RN55D-2002-F	341429-000
R4	Resistor MF 20.0k ohm 1%	---	RN55D-2002-F	341429-000
R5	Resistor MF 20.0k ohm 1%	---	RN55D-2002-F	341429-000
R6	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R7	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R8	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R9	Resistor Comp 12M ohm 5%	01121	CB	343708-000
R10	Resistor Comp 12M ohm 5%	01121	CB	343708-000
R11	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R12	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R13	Resistor MF 1.00k ohm 1%	---	RN55D-1001-F	341300-000
R14	Resistor MF 221 ohm 1%	---	RN55D-2210-F	341233-000
R15	Resistor MF 1.00k ohm 1%	---	RN55D-1001-F	341300-000
R16	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R17	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R18	Resistor MF 8.25k ohm 1%	---	RN55D-8251-F	341388-000
R20	Resistor MF 8.25k ohm 1%	---	RN55D-8251-F	341388-000
R22	Resistor MF 15.0k ohm 1%	---	RN55D-1502-F	341417-000
R23	Resistor MF 1.00M ohm 1%	---	RN55D-1004-F	341600-000
R24	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R25	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R26	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R27	Resistor MF 806k ohm 1%	---	RN55D-8063-F	341587-000
R28	Resistor Var 10k ohm 10% 0.5W	73138	72XWR10K	311348-000
R29	Resistor Var 25k ohm 10% 0.5W	73138	72XWR25K	311385-000
R36	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R37	Resistor MF 301k ohm 1%	---	RN55D-3013-F	341546-000
R38	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R39	Resistor MF 1.00k ohm 1%	---	RN55D-1001-F	341300-000
R40	Resistor Var 10k ohm 10% 0.5W	73138	72XWR10K	311348-000
TP1	Terminal (Test Point)	31313	TP-101-10	483258-000
TP2	Terminal (Test Point)	31313	TP-101-10	483258-000
TP3	Terminal (Test Point)	31313	TP-101-10	483258-000
TP7	Terminal (Test Point)	31313	TP-101-10	483258-000
TP12	Terminal (Test Point)	31313	TP-101-10	483258-000
TP13	Terminal (Test Point)	31313	TP-101-10	483258-000
TP14	Terminal (Test Point)	31313	TP-101-10	483258-000
TP16	Terminal (Test Point)	31313	TP-101-10	483258-000
TP17	Terminal (Test Point)	31313	TP-101-10	483258-000
U1	IC CD4532BE	02735	CD4532BE	534340-000
U2	IC IH6208CPE	32293	IH6208CPE	534266-000
U3	IC LF356 Op Amp IT/F 535052000	04901	BEC	535062-000
U4	IC LF356 Op Amp IT/F 535052000	04901	BEC	535062-000
U5	IC CD4011AE	02735	CD4011AE	534022-000
U6	IC LF356 Op Amp IT/F 535052000	04901	BEC	535079-000
U7	IC CD4001AE	02735	CD4001AE	534023-000
U8	IC CA3140AE Op Amp	02735	CA3140AE	535050-000
U9	IC IH6108CPE	32293	IH6108CPE	534265-000
U10	IC CD4047AE (RCA only)	02735	CD4047AE	534229-000
U11	IC CD4016BE	02735	RCA only	534218-000
U12	IC CD4030AE	02735	CD4030AE	534087-000
U13	IC CD4013BE (only)	02735	CD4013BE	534205-000
U14	IC 78L05AWC Regulator	07263	78L05AWC	535044-000
U15	IC 79L05ACP Regulator	04713	MC79L05ACP	535090-000
U16	IC CD4081BE	02735	CD4081BE	534142-000
U17	IC CA3140AE Op Amp	02735	CA3140AE	535050-000

Table 5-2. Replaceable Parts (Continued)

Replaceable Parts List for PWA Input Amplifier PL 042140-00A

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
XQ1	Socket IC 16 Pin	06776	ICN-163-S3-G	473042-000
XU1	Socket IC 16 Pin	06776	ICN-163-S3-G	473042-000
XU2	Socket IC 16 Pin	06776	ICN-163-S3-G	473042-000
XU3	Socket IC 8 Pin	06776	ICN-083-S3-G	473041-000
XU4	Socket IC 8 Pin	06776	ICN-083-S3-G	473041-000
XU5	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XU6	Socket IC 8 Pin	06776	ICN-083-S3-G	473041-000
XU7	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XU8	Socket IC 8 Pin	06776	ICN-083-S3-G	473041-000
XU9	Socket IC 16 Pin	06776	ICN-163-S3-G	473042-000
XU10	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XU11	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XU12	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XU13	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XU16	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XU17	Socket IC 8 Pin	06776	ICN-083-S3-G	473041-000

Replaceable Parts List for Input Resistor Network of 42B PL 042141-00A

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
R19	Resistor MF 1.65k ohm 1%	19701	5063J	338321-000
R21	Resistor MF 1.65k ohm 1%	19701	5063J	338321-000

Replaceable Parts List for Input Resistor Network of 42B PL 042142-00A

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
R30	Resistor MF 73.2k ohm 1%	19701	5063J	338483-000
R32	Resistor MF 19.1k ohm 1%	19701	5063J	338427-000
R33	Resistor MF 5.62k ohm 1%	19701	5063J	338372-000
R34	Resistor MF 1.33k ohm 1%	19701	5063J	338312-000
R35	Resistor MF 232 ohm 1%	19701	5063J	338235-000

Replaceable Parts List for PWA Master PL 042129-00B

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
C112	Capacitor EL 1000 µF -10/+50% 35V	57582	KSMM-1000-35	283350-000
C113	Capacitor EL 1000 µF -10/+50% 35V	57582	KSMM-1000-35	283350-000
C114	Capacitor EL 4700 µF -10%/+50% 16V	57582	KSMM-4700-16	283352-000
C115	Capacitor Cer 0.001 µF 500V	33883	Z5U B-GP Short Dip	224114-000
C116	Capacitor Cer 0.001 µF 500V	33883	Z5U B-GP Short Dip	224114-000
C117	Capacitor Tant 10 µF 20% 20V	56289	196D106X0020FB	283205-000
C118	Capacitor EL 100 µF 25V	56289	TE-1211 (30D107G025DD2)	283105-000
C119	Capacitor EL 100 µF 25V	56289	TE-1211 (30D107G025DD2)	283105-000
C120	Capacitor Cer 1.0 µF 20% 50V	04222	SR305E105MAA	224264-000
C121	Capacitor Cer 1.0 µF 20% 50V	04222	SR305E105MAA	224264-000
CR107	Diode 1N914	01295	1N914	530058-000
CR108	Diode 1N914	01295	1N914	530058-000
CR109	Diode 1N914	01295	1N914	530058-000
CR110	Diode 1N914	01295	1N914	530058-000
CR111	Diode Bridge KBP-02	20307	KBP-02	532013-000
CR112	Diode Bridge KBP-02	20307	KBP-02	532013-000
CR113	Diode Bridge KBP-02	20307	KBP-02	532013-000
CR114	Diode 1N914	01295	1N914	530058-000
CR115	Diode 1N914	01295	1N914	530058-000
CR116	Diode 1N914	01295	1N914	530058-000
CR118	Diode 1N914	01295	1N914	530058-000
CR119	Diode 1N914	01295	1N914	530058-000
CR120	Diode 1N914	01295	1N914	530058-000
CR121	Diode 1N914	01295	1N914	530058-000
CR122	Diode 1N914	01295	1N914	530058-000
CR123	Diode 1N914	01295	1N914	530058-000
CR124	Diode 1N914	01295	1N914	530058-000
CR125	Diode 1N914	01295	1N914	530058-000
IC103	IC µA7805UC Regulator & Hardware	07263	µA7805UC	535011-00A
IC104	IC LM723CN Regulator	27014	LM723CN	535037-000
IC105	IC LM723CN Regulator	27014	LM723CN	535037-000
IC106	IC 74L00N Quad 2 Input NAND	01295	SN74L00N	534002-000
J101	Connector 22 Pin	02660	143-022-07	479231-000
J102	Connector 22 Pin	02660	143-022-07	479231-000
J103	Connector 22 Pin	02660	143-022-07	479231-000
J104	Connector Female 44 pin card edge	02660	#225-22221-110	479254-000
Q103	Transistor PNP 2N5087	04713	2N5087	528042-000
Q106	Transistor PNP 2N5087	04713	2N5087	528042-000
Q122	Transistor PNP 2N5087	04713	2N5087	528042-000
Q123	Transistor PNP 2N5087	04713	2N5087	528042-000
Q125	Transistor PNP 2N5087	04713	2N5087	528042-000
Q126	Transistor PNP 2N5087	04713	2N5087	528042-000
Q127	Transistor PNP 2N5087	04713	2N5087	528042-000
Q128	Transistor PNP 2N5087	04713	2N5087	528042-000

Table 5-2. Replaceable Parts (Continued)

Replaceable Parts List for PWA Master PL 042129-00B

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
Q129	Transistor PNP 2N5087	04713	2N5087	528042-000
Q130	Transistor PNP 2N5087	04713	2N5087	528042-000
Q131	Transistor PNP 2N5087	04713	2N5087	528042-000
Q132	Transistor PNP 2N5087	04713	2N5087	528042-000
R102	Resistor MF 3.92k ohm 1%	---	RN55D-3921-F	341357-000
R103	Resistor MF 3.92k ohm 1%	---	RN55D-3921-F	341357-000
R136	Resistor MF 1.00k ohm 1%	---	RN55D-1001-F	341300-000
R137	Resistor MF 1.00k ohm 1%	---	RN55D-1001-F	341300-000
R138	Resistor Comp 5.1k ohm 5%	01121	EB	344368-000
R139	Resistor MF 3.32k ohm 1%	---	RN55D-3321-F	341350-000
R140	Resistor Var 1k ohm 10% 0.5W	73138	72PR1K	311316-000
R141	Resistor MF 3.01k ohm 1%	---	RN55D-3011-F	341346-000
R142	Resistor MF 3.32k ohm 1%	---	RN55D-3321-F	341350-000
R143	Resistor Var 1k ohm 10% 0.5W	73138	72PR1K	311316-000
R144	Resistor MF 3.01k ohm 1%	---	RN55D-3011-F	341346-000
R145	Resistor MF 9.09k ohm 1%	---	RN55D-9091-F	341392-000
R146	Resistor MF 162k ohm 1%	---	RN55D-1623-F	341520-000
R147	Resistor MF 39.2k ohm 1%	---	RN55D-3922-F	341457-000
R148	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R149	Resistor MF 162k ohm 1%	---	RN55D-1623-F	341520-000
R150	Resistor MF 39.2k ohm 1%	---	RN55D-3922-F	341457-000
R151	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R152	Resistor MF 162k ohm 1%	---	RN55D-1623-F	341520-000
R153	Resistor MF 39.2k ohm 1%	---	RN55D-3922-F	341457-000
R154	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R158	Resistor MF 162k ohm 1%	---	RN55D-1623-F	341520-000
R159	Resistor MF 39.2k ohm 1%	---	RN55D-3922-F	341457-000
R160	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R161	Resistor MF 162k ohm 1%	---	RN55D-1623-F	341520-000
R162	Resistor MF 39.2k ohm 1%	---	RN55D-3922-F	341457-000
R163	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R164	Resistor MF 162k ohm 1%	---	RN55D-1623-F	341520-000
R165	Resistor MF 39.2k ohm 1%	---	RN55D-3922-F	341457-000
R166	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R167	Resistor MF 162k ohm 1%	---	RN55D-1623-F	341520-000
R168	Resistor MF 39.2k ohm 1%	---	RN55D-3922-F	341457-000
R169	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R170	Resistor MF 162k ohm 1%	---	RN55D-1623-F	341520-000
R171	Resistor MF 39.2k ohm 1%	---	RN55D-3922-F	341457-000
R172	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R173	Resistor MF 162k ohm 1%	---	RN55D-1623-F	341520-000
R174	Resistor MF 39.2k ohm 1%	---	RN55D-3922-F	341457-000
R175	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R176	Resistor MF 162k ohm 1%	---	RN55D-1623-F	341520-000
R177	Resistor MF 39.2k ohm 1%	---	RN55D-3922-F	341457-000
R178	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R181	Resistor MF 1.82k ohm 1%	---	RN55D-1821-F	341325-000
R182	Resistor MF 1.82k ohm 1%	---	RN55D-1821-F	341325-000
R183	Resistor MF 4.75k ohm 1%	---	RN55D-4751-F	341365-000
R184	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R185	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
XIC101	Socket M/F (1/2) 473048	04901	BEC	473049-00B
XIC102	Socket M/F (1/2) 473048	04901	BEC	473049-00B
XIC104	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XIC105	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XIC106	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000

Replaceable Parts List for Shaping Amplifier Assembly PL 042026-01N

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
A501	IC LM301AN Op Amp	27014	LM301AN	535012-000
A502	IC LM301AN Op Amp	27014	LM301AN	535012-000
A503	IC LM310H Op Amp (only)	27014	LM310H	535005-000
C501	Capacitor Cer 0.01 µF 100V	32897	805-000X5V0103Z	224119-000
C502	Capacitor Cer 33 pF 5% 1 kV	56289	C030B102G330J (10TCC-Q33)	224139-000
C503	Capacitor Cer 0.01 µF 100V	32897	805-000X5V0103Z	224119-000
C504	Capacitor Cer 0.01 µF 100V	32897	805-000X5V0103Z	224119-000
C505	Capacitor Cer 33 pF 5% 1 kV	56289	C030B102G330J (10TCC-Q33)	224139-000
C506	Capacitor Cer 0.01 µF 100V	32897	805-000X5V0103Z	224119-000
CR501	Diode 1N914	01295	1N914	530058-000
CR502	Diode 1N914	01295	1N914	530058-000
CR503	Diode 1N914	01295	1N914	530058-000
CR504	Diode 1N914	01295	1N914	530058-000
CR505	Diode 1N914	01295	1N914	530058-000
CR506	Diode 1N914	01295	1N914	530058-000
CR507	Diode 1N914	01295	1N914	530058-000
CR508	Diode 1N914	01295	1N914	530058-000
CR509	Diode 1N914	01295	1N914	530058-000
CR510	Diode 1N914	01295	1N914	530058-000
Q501	Transistor NPN 2N5088	04713	2N5088	528047-000
Q502	Transistor NPN 2N5088	04713	2N5088	528047-000
Q503	Transistor FET 2N5949 N-Channel	04713	2N5949	528019-000

Table 5-2. Replaceable Parts (Continued)

Replaceable Parts List for Shaping Amplifier Assembly PL 042026-01N

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
Q504	Transistor FET 2N5949 N-Channel	04713	2N5949	528019-000
Q505	Transistor FET 2N5949 N-Channel	04713	2N5949	528019-000
Q506	Transistor FET 2N5949 N-Channel	04713	2N5949	528019-000
Q507	Transistor FET 2N5949 N-Channel	04713	2N5949	528019-000
Q508	Transistor FET 2N5949 N-Channel	04713	2N5949	528019-000
Q509	Transistor FET 2N5949 N-Channel	04713	2N5949	528019-000
Q510	Transistor NPN 2N5088	04713	2N5088	528047-000
Q511	Transistor NPN 2N5088	04713	2N5088	528047-000
Q512	Transistor NPN 2N5088	04713	2N5088	528047-000
Q513	Transistor NPN 2N5088	04713	2N5088	528047-000
Q514	Transistor JFET 2N5953	04901	BEC	528145-000
Q515	Transistor NPN 2N5088	04713	2N5088	528047-000
Q516	Transistor JFET 2N5953	04901	BEC	528145-000
Q517	Transistor NPN 2N5088	04713	2N5088	528047-000
Q518	Transistor JFET 2N5953	04901	BEC	528145-000
Q519	Transistor NPN 2N5088	04713	2N5088	528047-000
Q520	Transistor JFET 2N5953	04901	BEC	528145-000
Q521	Transistor NPN 2N5088	04713	2N5088	528047-000
Q522	Transistor NPN 2N5088	04713	2N5088	528047-000
Q523	Transistor NPN 2N5088	04713	2N5088	528047-000
Q524	Transistor NPN 2N5088	04713	2N5088	528047-000
Q525	Transistor NPN 2N5088	04713	2N5088	528047-000
Q526	Transistor JFET 2N5953	04901	BEC	528145-000
Q527	Transistor NPN 2N5088	04713	2N5088	528047-000
Q528	Transistor NPN 2N5088	04713	2N5088	528047-000
Q529	Transistor NPN 2N5088	04713	2N5088	528047-000
Q530	Transistor NPN 2N5088	04713	2N5088	528047-000
Q531	Transistor NPN 2N5088	04713	2N5088	528047-000
Q532	Transistor NPN 2N5088	04713	2N5088	528047-000
Q533	Transistor FET 2N5949 N-Channel	04713	2N5949	528019-000
Q534	Transistor FET 2N5949 N-Channel	04713	2N5949	528019-000
R501	Resistor Comp 4.7M ohm 5%	01121	EB	344665-000
R502	Resistor Comp 4.7M ohm 5%	01121	EB	344665-000
R503	Resistor Comp 4.7M ohm 5%	01121	EB	344665-000
R504	Resistor Comp 4.7M ohm 5%	01121	EB	344665-000
R505	Resistor Comp 4.7M ohm 5%	01121	EB	344665-000
R506	Resistor Comp 4.7M ohm 5%	01121	EB	344665-000
R507	Resistor Comp 4.7M ohm 5%	01121	EB	344665-000
R508	Resistor MF 8.66k ohm 1%	---	RN55D-8661-F	341390-000
R509	Resistor MF 8.66k ohm 1%	---	RN55D-8661-F	341390-000
R510	Resistor MF 9.53k ohm 1%	---	RN55D-9531-F	341394-000
R511	Resistor MF 165k ohm 1%	---	RN55D-1653-F	341521-000
R512	Resistor MF 866k ohm 1%	---	RN60D-8663-F	342590-000
R513	Resistor MF 499k ohm 1%	---	RN55D-4993-F	341567-000
R514	Resistor MF 49.9k ohm 1%	---	RN55D-4992-F	341467-000
R515	Resistor MF 4.99k ohm 1%	---	RN55D-4991-F	341367-000
R516	Resistor MF 210k ohm 1%	---	RN55D-2103-F	341531-000
R517	Resistor MF 536k ohm 1%	---	RN60D-5363-F	342570-000
R518	Resistor MF 13.0k ohm 1%	---	RN55D-1302-F	341411-000
R519	Resistor Var 2k ohm 10% 1W	91637	ǂ784	311264-000
R520	Resistor Var 2k ohm 10% 1W	91637	ǂ784	311264-000
R521	Resistor Var 2k ohm 10% 1W	91637	ǂ784	311264-000
R522	Resistor Var 2k ohm 10% 1W	91637	ǂ784	311264-000
R523	Resistor Var 2k ohm 10% 1W	91637	ǂ784	311264-000
R524	Resistor Var 2k ohm 10% 1W	91637	ǂ784	311264-000
R525	Resistor Var 2k ohm 10% 1W	91637	ǂ784	311264-000
R526	Resistor MF 3.01k ohm 1%	---	RN55D-3011-F	341346-000
R527	Resistor MF 3.57k ohm 1%	---	RN55D-3571-F	341353-000
R528	Resistor MF 3.92k ohm 1%	---	RN55D-3921-F	341357-000
R529	Resistor MF 6.04k ohm 1%	---	RN55D-6041-F	341375-000
R530	Resistor Comp 180 ohm 5%	01121	EB	344225-000
R531	Resistor MF 84.5k ohm 1%	---	RN55D-8452-F	341489-000
R532	Resistor MF 787k ohm 1%	---	RN60D-7873-F	342586-000
R533	Resistor MF 78.7k ohm 1%	---	RN55D-7872-F	341486-000
R534	Resistor MF 392k ohm 1%	---	RN55D-3923-F	341557-000
R535	Resistor Comp 1.0M ohm 5%	01121	EB	344600-000
R536	Resistor MF 143k ohm 1%	---	RN55D-1433-F	341515-000
R537	Resistor MF 536k ohm 1%	---	RN60D-5363-F	342570-000
R538	Resistor MF 54.9k ohm 1%	---	RN55D-5492-F	341471-000
R539	Resistor MF 154k ohm 1%	---	RN55D-1543-F	341518-000
R540	Resistor Comp 1.0M ohm 5%	01121	EB	344600-000
R541	Resistor MF 90.9k ohm 1%	---	RN55D-9092-F	341492-000
R542	Resistor MF 210k ohm 1%	---	RN55D-2103-F	341531-000
R543	Resistor Var 20k ohm 10% 1W	91637	ǂ784	311266-000
R544	Resistor MF 21.0k ohm 1%	---	RN55D-2102-F	341431-000
R545	Resistor Comp 1.0M ohm 5%	01121	EB	344600-000
R546	Resistor MF 38.3k ohm 1%	---	RN55D-3832-F	341456-000
R547	Resistor MF 274k ohm 1%	---	RN55D-2743-F	341542-000
R548	Resistor Var 20k ohm 10% 1W	91637	ǂ784	311266-000
R549	Resistor MF 48.7k ohm 1%	---	RN55D-4872-F	341466-000
R550	Resistor MF 226k ohm 1%	---	RN55D-2263-F	341534-000
R551	Resistor MF 35.7k ohm 1%	---	RN55D-3572-F	341453-000

Table 5-2. Replaceable Parts (Continued)

Replaceable Parts List for Shaping Amplifier Assembly PL 042026-01N

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
R552	Resistor MF 118k ohm 1%	---	RN55D-1183-F	341507-000
R553	Resistor MF 45.3k ohm 1%	---	RN55D-4532-F	341463-000
R554	Resistor MF 110k ohm 1%	---	RN55D-1103-F	341504-000
R555	Resistor MF 36.5k ohm 1%	---	RN55D-3652-F	341454-000
R556	Resistor MF 73.2k ohm 1%	---	RN55D-7322-F	341483-000
R557	Resistor MF 25.5k ohm 1%	---	RN55D-2552-F	341439-000
R558	Resistor Comp 1.0M ohm 5%	01121	EB	344600-000
R559	Resistor Comp 10k ohm 5%	01121	EB	344400-000
R560	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R561	Resistor MF 158k ohm 1%	---	RN55D-1582-F	341519-000
R562	Resistor Var 20k ohm 10% 1W	91637	#784	311266-000
R563	Resistor Comp 5.1k ohm 5%	01121	EB	344368-000
R564	Resistor Comp 5.1k ohm 5%	01121	EB	344368-000
R565	Resistor MF 39.2k ohm 1%	---	RN55D-3922-F	341457-000
R566	Resistor MF 169k ohm 1%	---	RN55D-1693-F	341522-000
R567	Resistor MF 7.87k ohm 1%	---	RN55D-7871-F	341386-000
R568	Resistor MF 32.4k ohm 1%	---	RN55D-3242-F	341449-000
R569	Resistor MF 97.6k ohm 1%	---	RN55D-9762-F	341495-000
R570	Resistor MF 40.2k ohm 1%	---	RN55D-4022-F	341458-000
R571	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R572	Resistor Comp 4.7k ohm 5%	01121	EB	344365-000
R573	Resistor Var 5k ohm 20% 0.5W	32997	3359W-1-502	311293-000
R574	Resistor MF 27.4k ohm 1%	---	RN55D-2742-F	341442-000
R575	Resistor MF 56.2k ohm 1%	---	RN55D-5622-F	341472-000
R576	Resistor Comp 5.1k ohm 5%	01121	CB	343368-000
R577	Resistor Comp 5.1k ohm 5%	01121	CB	343368-000
R578	Resistor MF 3.01k ohm 1%	---	RN55D-3011-F	341346-000
RT501	Thermistor 100 ohm ±10%	00241	CB21J1	325005-000

Replaceable Parts List for PWA Digital Control Board 42BD PL 042050-01F

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
A604	IC LM301AN Op Amp	27014	LM301AN	535012-000
A605	IC LM301AN Op Amp	27014	LM301AN	535012-000
C606	Capacitor Cer 0.01 µF 100V	32897	805-000X5V0103Z	224119-000
C607	Capacitor Cer 0.01 µF 100V	32897	805-000X5V0103Z	224119-000
CR601	Diode Zener 1N5236B 7.5V	04713	1N5236B	530087-000
CR603	Diode Zener 1N5227B 3.6V	04713	1N5227B	530095-000
CR604	Diode Zener 1N5227B 3.6V	04713	1N5227B	530095-000
IC601	IC 7409N Quad 2 Input AND	01295	SN7409N	534043-000
IC602	IC CD5024AE	02735	CD5024AE	534065-000
IC603	IC SN74L42N	01295	SN74L42N	534064-000
IC604	IC SN74L10N	01295	SN74L10N	534029-000
IC605	IC CD4016AE Quad Switch	02735	CD4016AE	534007-000
IC606	IC 74L00N Quad 2 Input NAND	01295	SN74L00N	534002-000
Q602	Transistor FET 2N5653	04713	2N5653	528056-000
Q604	Transistor FET 2N5653	04713	2N5653	528056-000
Q606	Transistor FET 2N5653	04713	2N5653	528056-000
Q607	Transistor PNP 2N3905	04713	2N3905	528025-000
Q608	Transistor FET 2N5653	04713	2N5653	528056-000
Q609	Transistor PNP 2N3905	04713	2N3905	528025-000
R602	Resistor Comp 4.7k ohm 5%	01121	EB	344365-000
R604	Resistor Comp 4.7k ohm 5%	01121	EB	344365-000
R606	Resistor Comp 4.7k ohm 5%	01121	EB	344365-000
R607	Resistor Comp 4.7k ohm 5%	01121	EB	344365-000
R608	Resistor Comp 100k ohm 5%	01121	EB	344500-000
R609	Resistor Comp 15k ohm 5%	01121	EB	344417-000
R614	Resistor Comp 100k ohm 5%	01121	EB	344500-000
R615	Resistor Comp 100k ohm 5%	01121	EB	344500-000
R619	Resistor Comp 100k ohm 5%	01121	EB	344500-000
R620	Resistor Comp 10k ohm 5%	01121	EB	344400-000
R621	Resistor Comp 4.7k ohm 5%	01121	EB	344365-000
R626	Resistor MF 953 ohm 1%	---	RN55D-9530-F	341294-000
R631	Resistor MF 19.1k ohm 1%	---	RN55D-1912-F	341427-000
R632	Resistor MF 13.0k ohm 1%	---	RN55D-1302-F	341411-000
R633	Resistor MF 4.75k ohm 1%	---	RN55D-4751-F	341365-000
R634	Resistor Comp 10k ohm 5%	01121	EB	344400-000
R635	Resistor MF 33.2k ohm 1%	---	RN55D-3322-F	341450-000
R636	Resistor MF 76.8k ohm 1%	---	RN55D-7682-F	341485-000
R637	Resistor Comp 10k ohm 5%	01121	EB	344400-000
R638	Resistor MF 9.76k ohm 1%	---	RN55D-9761-F	341395-000
R639	Resistor Var 2k ohm 10% 1W	91637	#784	311264-000
R643	Resistor Var 100 ohm 10% 1W	91637	#784	311383-000
XA604	Socket IC 8 Pin	06776	ICN-083-S3-G	473041-000
XA605	Socket IC 8 Pin	06776	ICN-083-S3-G	473041-000
XA605	Socket IC 8 Pin	06776	ICN-083-S3-G	473041-000
XIC601	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XIC602	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XIC602	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XIC603	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XIC603	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XIC604	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000

Table 5-2. Replaceable Parts (Continued)

Replaceable Parts List for PWA Digital Control Board 42BD PL 042050-01F

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
XIC604	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XIC605	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XIC605	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000

Replaceable Parts List for PWA Digital Control Board 42CD PL 042050-02F

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
Q612	Transistor PNP 2N5087	04713	2N5087	528042-000
Q613	Transistor PNP 2N5087	04713	2N5087	528042-000
R641	Resistor MF 4.75k ohm 1%	---	RN55D-4751-F	341365-000
R642	Resistor MF 4.75k ohm 1%	---	RN55D-4751-F	341365-000

Replaceable Parts List for PWA Counter PL 093006-00F

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
*	* SELECTED PART			-
C1201	Capacitor Tant 200 µF -10/+75 6V	56289	TE-1104	283147-000
C1203	Capacitor Var 4.5-50 pF 250V	91293	9305 (Green)	281009-000
C1204	Capacitor Mica 33 pF 5% 500V	20307	DM15-330J	200049-000
C1205	Capacitor Mylar .01 µF 20% 250V	19701	C280AE/P10K	234085-000
C1206	Capacitor Mylar 0.1 µF 10% 100V (only)	19701	C280MAH/A100K (only)	234080-000
C1207	Capacitor Cer 33 pF 10% 100V	04222	MC71A330K	224218-000
C1208	Capacitor Tant 47 µF 10% 20V (only)	56289	196D476X9020PE4	283219-000
C1209	Capacitor Tant 10 µF 20% 20V	56289	196D106X0020FB	283205-000
C1202*	Capacitor Mica 120 pF 5% 500V	20307	DM15-F121J	200002-000
C1202*	Capacitor Mica 56 pF 5% 500V	20307	DM15-560J	200030-000
C1202*	Capacitor Mica 150 pF 5% 500V	20307	DM15-151J	200032-000
C1202*	Capacitor Mica 91 pF 5% 500V	20307	DM15-910J	200035-000
C1202*	Capacitor Mica 33 pF 5% 500V	20307	DM15-330J	200049-000
CR1201	Diode Zener 1N5234B 6.2V	04713	1N5234B	530093-000
CR1202	Diode Zener 1N5234B 6.2V	04713	1N5234B	530093-000
CR1203	Diode 1N914	01295	1N914	530058-000
CR1204	Diode 1N914	01295	1N914	530058-000
IC1201	IC 74L00N Quad 2 Input NAND	01295	SN74L00N	534002-000
IC1202	IC MK5002P	50088	MK5002P	534024-000
J1202	Connector Receptacle (female)	32575	583485-8	479277-000
J1203	Connector Receptacle (female)	32575	583485-8	479277-000
J1204	Connector Receptacle (female)	32575	583485-8	479277-000
Q1201	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1202	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1203	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1204	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1205	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1206	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1207	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1208	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1209	Transistor NPN MPS6507	04713	MPS6507	528070-000
Q1210	Transistor NPN 2N5088	04713	2N5088	528047-000
Q1211	Transistor NPN 2N5088	04713	2N5088	528047-000
Q1212	Transistor NPN 2N5088	04713	2N5088	528047-000
Q1213	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1214	Transistor NPN 2N5088	04713	2N5088	528047-000
Q1215	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1216	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1217	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1218	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1219	Transistor NPN 2N5088	04713	2N5088	528047-000
Q1220	Transistor UJT MPU-131	04713	MPU-131	528062-000
Q1221	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1222	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1223	Transistor PNP 2N5087	04713	2N5087	528042-000
Q1224	Transistor PNP 2N5087	04713	2N5087	528042-000
R1201	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1202	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1203	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1204	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1205	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1206	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1207	Resistor MF 2.00k ohm 1%	---	RN55D-2001-F	341329-000
R1208	Resistor MF 1.00k ohm 1%	---	RN55D-1001-F	341300-000
R1209	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000
R1210	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000
R1211	Resistor MF 75.0k ohm 1%	---	RN55D-7502-F	341484-000
R1212	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R1213	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R1214	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R1215	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1216	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000
R1217	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000
R1218	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000
R1219	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000
R1220	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000

Table 5-2. Replaceable Parts (Continued)

Replaceable Parts List for PWA Counter PL 093006-00P

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
R1221	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1222	Resistor MF 3.01k ohm 1%	---	RN55D-3011-F	341346-000
R1223	Resistor MF 681 ohm 1%	---	RN55D-6810-F	341280-000
R1224	Resistor MF 432 ohm 1%	---	RN55D-4320-F	341261-000
R1225	Resistor MF 681K ohm 1%	---	RN55D-6813-F	341580-000
R1226	Resistor MF 100k ohm 1%	---	RN55D-1003-F	341500-000
R1227	Resistor MF 681K ohm 1%	---	RN55D-6813-F	341580-000
R1228	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000
R1229	Resistor MF 332 ohm 1%	---	RN55D-3320-F	341250-000
R1230	Resistor Comp 4.7M ohm 5%	01121	CB	343665-000
R1231	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000
R1232	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000
R1233	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000
R1234	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000
R1235	Resistor MF 432 ohm 1%	---	RN55D-4320-F	341261-000
XU1201	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XU1202	Socket IC 28 Pin	06776	ICN-286-S4-G	473044-000

Replaceable Parts List for PWA A/D Converter PL 093007-01K

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
A1401	IC LM310H Op Amp (only)	27014	LM310H	535005-000
A1402	IC LM301AN Op Amp	27014	LM301AN	535012-000
A1403	IC LM310H Op Amp (only)	27014	LM310H	535005-000
A1404	IC LM311H Voltage Comparator	27014	LM311H	535006-000
C1401	Capacitor Tant 1 µF 10% 35V only	56289	196D105X9035HA1 only	283216-000
C1402	Capacitor Tant 1 µF 10% 35V only	56289	196D105X9035HA1 only	283216-000
C1403	Capacitor .01µf 10% 50V	84411	X463UW	234115-000
C1404	Capacitor Cer 33 pF 5% 1 kV	56289	C030B102G330J (10TCC-Q33)	224139-000
C1405	Capacitor Tant 1 µF 10% 35V only	56289	196D105X9035HA1 only	283216-000
C1406	Capacitor .01µf 10% 50V	84411	X463UW	234115-000
C1407	Capacitor Mica 100 pF 5% 300V	20307	DM5-FC101J	205006-000
CR1401	Diode 1N821	08077	1N821	530050-000
CR1402	Diode 1N821	08077	1N821	530050-000
CR1403	Diode 1N914	01295	1N914	530058-000
CR1404	Diode 1N914	01295	1N914	530058-000
CR1405	Diode 1N914	01295	1N914	530058-000
IC1401	IC CD4016AE Quad Switch	02735	CD4016AE	534007-000
IC1402	IC CD4013AE	02735	CD4013AE	534021-000
IC1403	IC CD4011AE	02735	CD4011AE	534022-000
IC1404	IC CD4001AE	02735	CD4001AE	534023-000
Q1401	Transistor JFET 2N5953	04901	BEC	528145-000
R1401	Resistor MF 30.9k ohm 1%	---	RN55D-3092-F	341447-000
R1402	Resistor MF 30.9k ohm 1%	---	RN55D-3092-F	341447-000
R1403	Resistor MF 5.49k ohm 1%	---	RN55D-5491-F	341371-000
R1404	Resistor MF 5.49k ohm 1%	---	RN55D-5491-F	341371-000
R1405	Resistor Var 5k ohm 20% 0.5W	32997	3359W-1-502	311293-000
R1406	Resistor MF 1.15k ohm 1%	---	RN55D-1151-F	341306-000
R1407	Resistor MF 200k ohm 1%	---	RN55D-2003-F	341529-000
R1408	Resistor Var 5k ohm 20% 0.5W	32997	3359W-1-502	311293-000
R1409	Resistor MF 332 ohm 1%	---	RN55D-3320-F	341250-000
R1410	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R1411	Resistor MF 1.15k ohm 1%	---	RN55D-1151-F	341306-000
R1412	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1413	Resistor Comp 4.7M ohm 5%	01121	CB	343665-000
R1414	Resistor MF 681 ohm 1%	---	RN55D-6810-F	341280-000
R1415	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1416	Resistor MF 5.11k ohm 1%	---	RN55D-5111-F	341368-000
R1417	Resistor MF 10.0k ohm 1%	---	RN55D-1002-F	341400-000
R1418	Resistor Comp 4.7M ohm 5%	01121	CB	343665-000
R1419	Resistor MF 1.00M ohm 1%	---	RN55D-1004-F	341600-000
R1420	Resistor MF 47.5k ohm 1%	---	RN55D-4752-F	341465-000
XA1402	Socket IC 8 Pin	06776	ICN-083-S3-G	473041-000
XU1401	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XU1402	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XU1403	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XU1404	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000

Replaceable Parts List for PWA Display PL 093008-01L

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
C1301	Capacitor Tant 10 µF 20% 20V	56289	196D106X0020FB	283205-000
CR1301	Diode 1N914	01295	1N914	530058-000
CR1302	Diode 1N914	01295	1N914	530058-000
CR1303	Diode 1N914	01295	1N914	530058-000
CR1304	Diode 1N914	01295	1N914	530058-000
DS1301	Display Numeric MAN-3620	34430	MAN-3620	536805-000
DS1302	Display Numeric MAN-3620	34430	MAN-3620	536805-000
DS1303	Display Numeric MAN-3620	34430	MAN-3620	536805-000
DS1304	Lamp 5V 583DX	01139	583D-120	545127-000
DS1305	Lamp 5V 2200D	01139	T1 1.75	545120-000
DS1306	Lamp 5V 2200D	01139	T1 1.75	545120-000
DS1307	Lamp 5V 2200D	01139	T1 1.75	545120-000

Table 5-2. Replaceable Parts (Continued)

Replaceable Parts List for PWA Display — PL 093008-01L

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
DS1308	Display Numeric MAN-3620	34430	MAN-3620	536805-000
DS1309	Lamp 5V 2200D	01139	T1 1.75	545120-000
DS1310	Lamp 5V 2200D	01139	T1 1.75	545120-000
DS1311	Lamp 5V 2200D	01139	T1 1.75	545120-000
L1301	Inductor 33 µH 5%	59474	4465-2J	400310-000
Q1301	Transistor NPN 2N5088	04713	2N5088	528047-000
Q1302	Transistor NPN 2N5088	04713	2N5088	528047-000
Q1303	Transistor NPN 2N5088	04713	2N5088	528047-000
Q1304	Transistor NPN 2N5088	04713	2N5088	528047-000
Q1305	Transistor NPN 2N5088	04713	2N5088	528047-000
Q1306	Transistor NPN 2N5088	04713	2N5088	528047-000
Q1307	Transistor NPN 2N5088	04713	2N5088	528047-000
Q1308	Transistor NPN MPS-A12	04713	MPS-A12	528052-000
Q1309	Transistor NPN MPS-A12	04713	MPS-A12	528052-000
Q1310	Transistor NPN MPS-A12	04713	MPS-A12	528052-000
Q1311	Transistor NPN MPS-A12	04713	MPS-A12	528052-000
Q1312	Transistor PNP 2N5087	04713	2N5087	528042-000
R1301	Resistor MF 47.5 ohm 1%	---	RN55D-47R5-F	341165-000
R1302	Resistor MF 47.5 ohm 1%	---	RN55D-47R5-F	341165-000
R1303	Resistor MF 47.5 ohm 1%	---	RN55D-47R5-F	341165-000
R1304	Resistor MF 47.5 ohm 1%	---	RN55D-47R5-F	341165-000
R1305	Resistor MF 47.5 ohm 1%	---	RN55D-47R5-F	341165-000
R1306	Resistor MF 47.5 ohm 1%	---	RN55D-47R5-F	341165-000
R1307	Resistor MF 47.5 ohm 1%	---	RN55D-47R5-F	341165-000
R1308	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1309	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1310	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1311	Resistor MF 26.7k ohm 1%	---	RN55D-2672-F	341441-000
R1312	Resistor MF 33.2 ohm 1%	---	RN55D-33R2-F	341150-000
XD1301	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XD1302	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XD1303	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000
XD1308	Socket IC 14 Pin	06776	ICN-143-S3-G	473019-000

Replaceable Parts List for Switch Assembly — PL 042123-02B

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
S401	Switch Modified M/F 465153	04901	PB-10 (Centralab Modified)	465154-00A

Replaceable Parts List for Meter Assembly — PL 042125-01B

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
M401	Meter & Scale M/F 554253, 554284	04901	BEC	554287-00A

Replaceable Parts List for Chopper Assembly — PL 042161-01G

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
C1	Capacitor PP 0.1 µF 10% 100V	27735	PP11-.1-100-10	234148-000
C2	Capacitor PP 0.1 µF 10% 100V	27735	PP11-.1-100-10	234148-000
IC1	IC CD4016BE (only) IT/F 534354 PED4200-3	04901	BEC	534223-000
P1-1	Terminal	98291	229-1071-23	510038-000
P1-2	Terminal	98291	229-1071-23	510038-000
P1-3	Terminal	98291	229-1071-23	510038-000
P1-4	Terminal	98291	229-1071-23	510038-000
P1-5	Terminal	98291	229-1071-23	510038-000
P1-6	Terminal	98291	229-1071-23	510038-000
P1-7	Terminal	98291	229-1071-23	510038-000
R3	Resistor MF 51.1k ohm 1%	---	RN55D-5112-F	341468-000
R4	Resistor Var 20k ohm 10% 0.5W	73138	72PR20K	311354-000
R5	Resistor Var 20k ohm 10% 0.5W	73138	72PR20K	311354-000
R6	Resistor MF 51.1k ohm 1%	---	RN55D-5112-F	341468-000
XIC1	Socket IC 14 Pin	91506	508-AG7D	473056-000

Replaceable Parts List for Rear Panel Assembly — PL 042023-02B

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
F401	Fuse 0.2 A	54426	MDL 0.2	545508-000
F401	Fuse 0.1 A Slo-Blo	54426	MDL	545519-000
S402	Switch Slide	82389	46202LR	465134-000
T401	Transformer Power	04901	BEC	446071-000

Replaceable Parts List for Sub Panel Assembly — PL 042024-02B

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
J401	Connector Assembly (female)	04901	BEC	092141-01B
R402	Resistor Var 5k ohm 10% 1W	99942	BA-0251-0001	311407-000

Replaceable Parts List for Harness Assembly — PL 042126-01C

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
J1201	Connector 44 Pin	02660	225-22221-101	479259-000

Table 5-2. Replaceable Parts (Continued)

Replaceable Parts List for Heatsink Assembly PL 042144-00B

Reference Symbol	Description	Mfr.	Mfr's Part No.	BEC Part No.
IC101	IC µA7805UC Regulator & Hardware	07263	µA7805UC	535011-00A
IC102	IC µA7805UC Regulator & Hardware	07263	µA7805UC	535011-00A

S E C T I O N VI

SCHEMATIC DIAGRAMS

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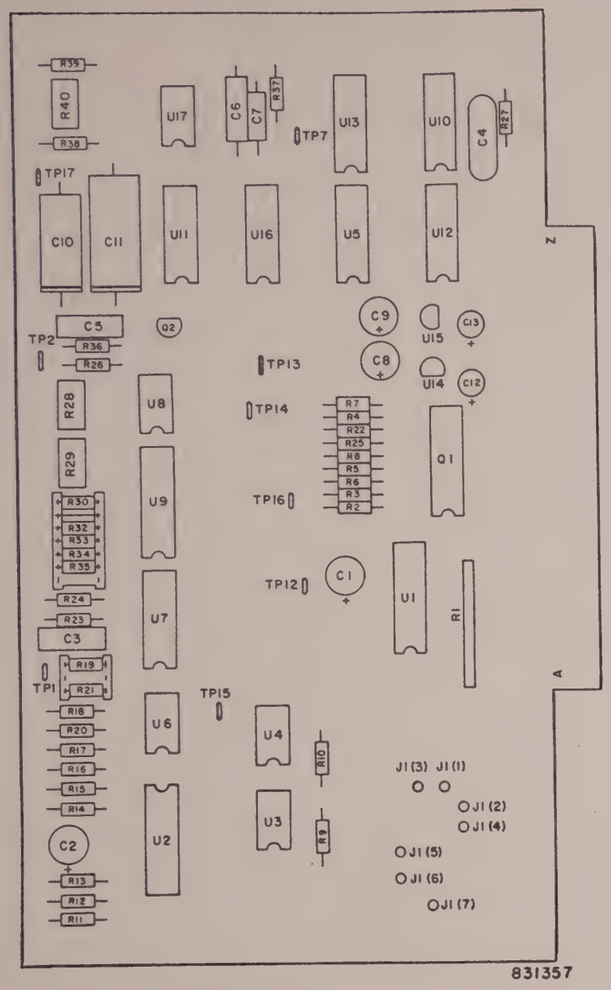
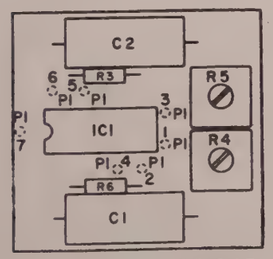
NOTES



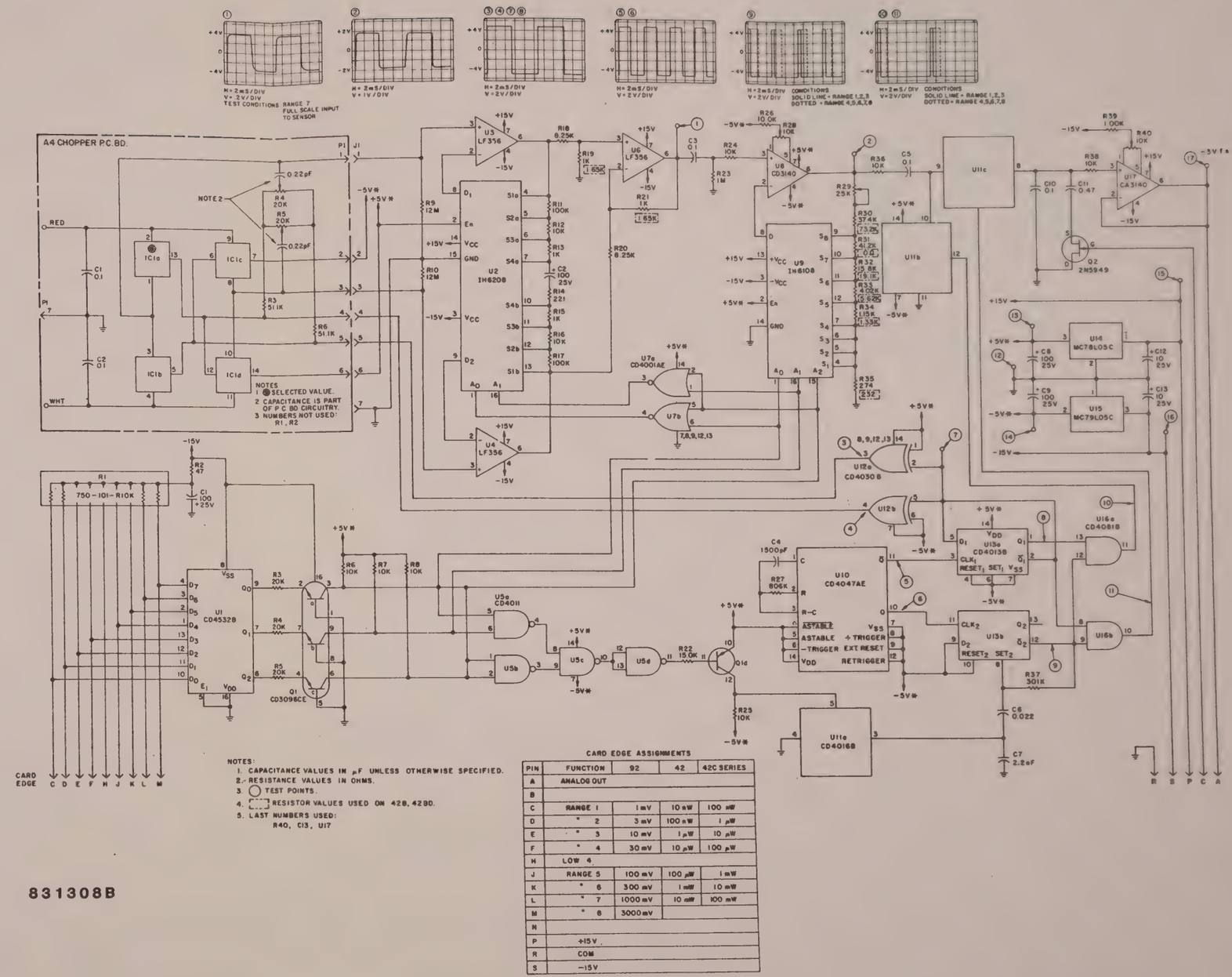
831357

Input Amplifier Parts-Location Diagram (C831357B)



831045

Chopper Board Parts-Location Diagram (B831045D)



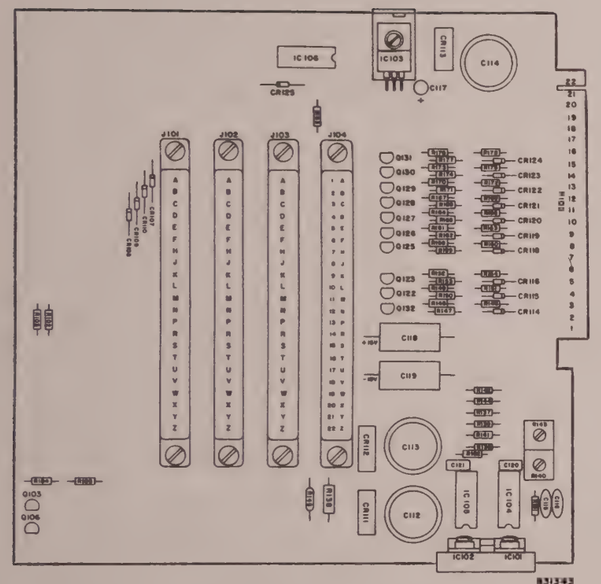
NOTES:
1. CAPACITANCE VALUES IN μF UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. ○ TEST POINTS.
4. [ ] RESISTOR VALUES USED ON 42B, 42BD.
5. LAST NUMBERS USED: R40, C13, U17

CARD EDGE ASSIGNMENTS

PIN	FUNCTION	92	42	42C SERIES
A	ANALOG OUT			
B				
C	RANGE 1	1 mV	10 nW	100 nW
D	" 2	3 mV	100 nW	1 μW
E	" 3	10 mV	1 μW	10 μW
F	" 4	30 mV	10 μW	100 μW
H	LOW 4			
J	RANGE 5	100 mV	100 μW	1 mW
K	" 6	300 mV	1 mW	10 mW
L	" 7	1000 mV	10 mW	100 mW
M	" 8	3000 mV		
N				
P	+15V			
R	COM			
S	-15V			

831308B

Figure 6-1. Input Amplifier Board Parts-Location and Schematic Diagram and Chopper Board Parts-Location Diagram



Parts-Location Diagram (D831343A)

DVM AND AMPLIFIER PCB INTERCONNECTION TABLE

J1201 DVM CONNECTOR							
J1201	PCB	WIRE	FUNCTION	J1201	PCB	WIRE	FUNCTION
1	38	WHT/BLK/GY	ENCODE				
1	54	WHT/YEL	COMPLETE	A	51	WHT/BRN	- dBm
2	52	WHT/BLK	+5V	B	55	WHT/GRN	+5V
3	13	ORN	"△" NOT	C	18	GY	"μW" NOT
4	14	YEL	PWR MODE	D	22	WHT/RED	"mW" NOT
5	21	WHT/BRN	"nW" NOT	E	J1201-7	JUMPER	"▽" NOT
6	J1201-3	JUMPER	"△" NOT	F	17	VIO	DP1
7	12	RED	"▽" NOT	H	16	BLU	DP2
8	NC			J	15	GRN	DP3
9	57	WHT/VIO	GND	K	NC		
10	37	WHT/BLK/VIO	ENCODE HOLD	L	26	WHT/BLU	+15V
11	NC			M	28	WHT/GY	-15V
12	50	BLK	GND	N	J1201-16	JUMPER	SIGNAL LOW
13	J1201-N	JUMPER		P	32	WHT/BLK/RED	SIGNAL HIGH
14	NC			R	NC		
15	NC			S	53	WHT/ORN	ENCODE TRIG
16	J1201-N	JUMPER	GND	T	27	GRN/YEL	GND
17	J1201-U	JUMPER	+EDGEMETER	U	34	WHT/BLK/YEL	+EDGEMETER
18	NC		DIGIT SELECT	V	NC		BCD
19	41	BRN	1	W	45	GRN	8
20	42	RED	2	X	46	BLU	4
21	43	ORN	3	Y	47	VIO	2
22	44	YEL	4	Z	48	GY	1

NOTES:
1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3. ☐ EXTERNAL MARKINGS.
4. TEST CONDITIONS:
   RANGE: 1μW } 42BD, 10μW } 42CD
   SIGNAL: 1μW } 42BD, 10μW } 42CD
   ALL VOLTAGE READINGS IN VOLTS, UNLESS OTHERWISE SPECIFIED. ALL READINGS NOMINAL.
5. ⁘ 42CD ONLY
6. LAST NUMBERS USED:
   R185, C121
   R402
7. NUMBERS NOT USED:
   R101, R104 THRU R135, R155, 156, 157
   C101 THRU C111
   Q101, 102, 104, 105, 107 THRU Q121, Q124
   CR101 THRU CR106, CR117

831314A

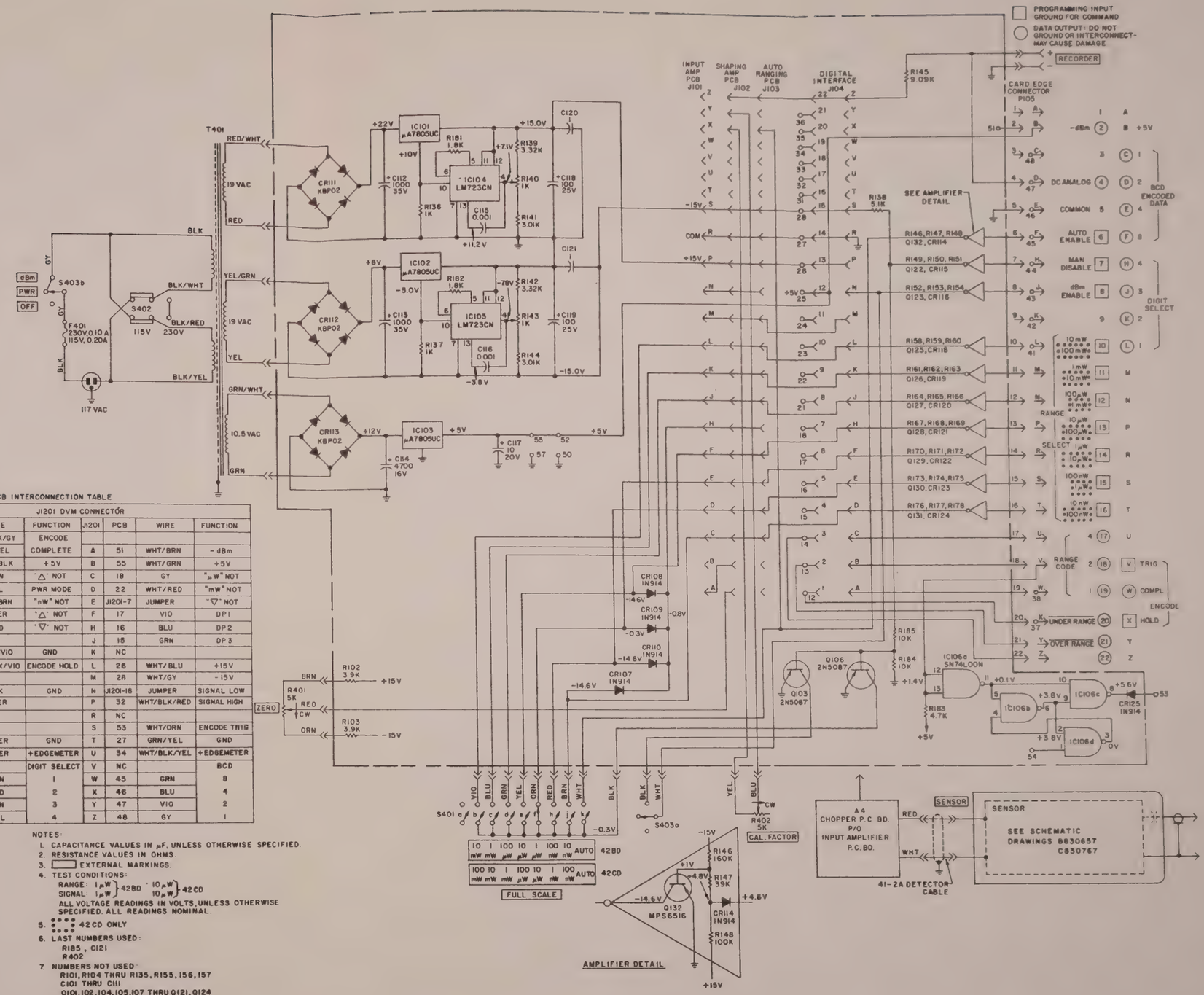
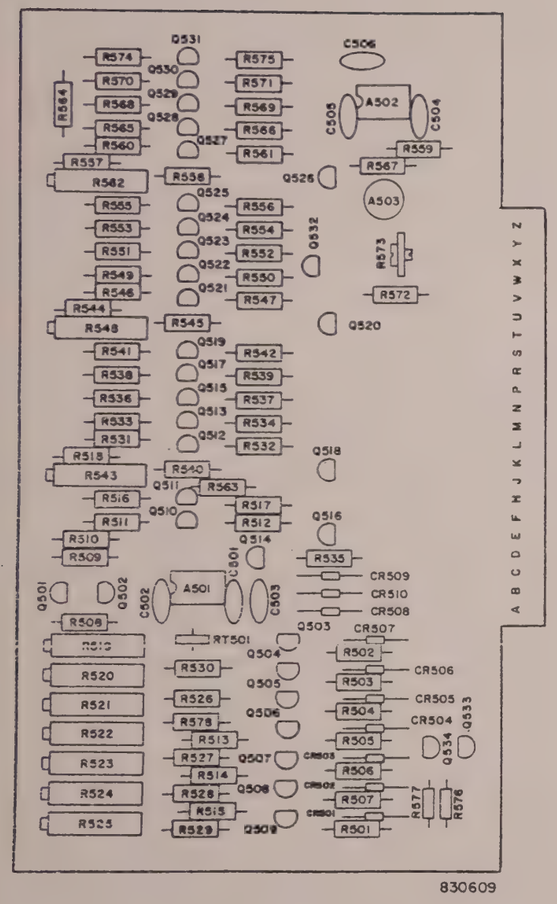
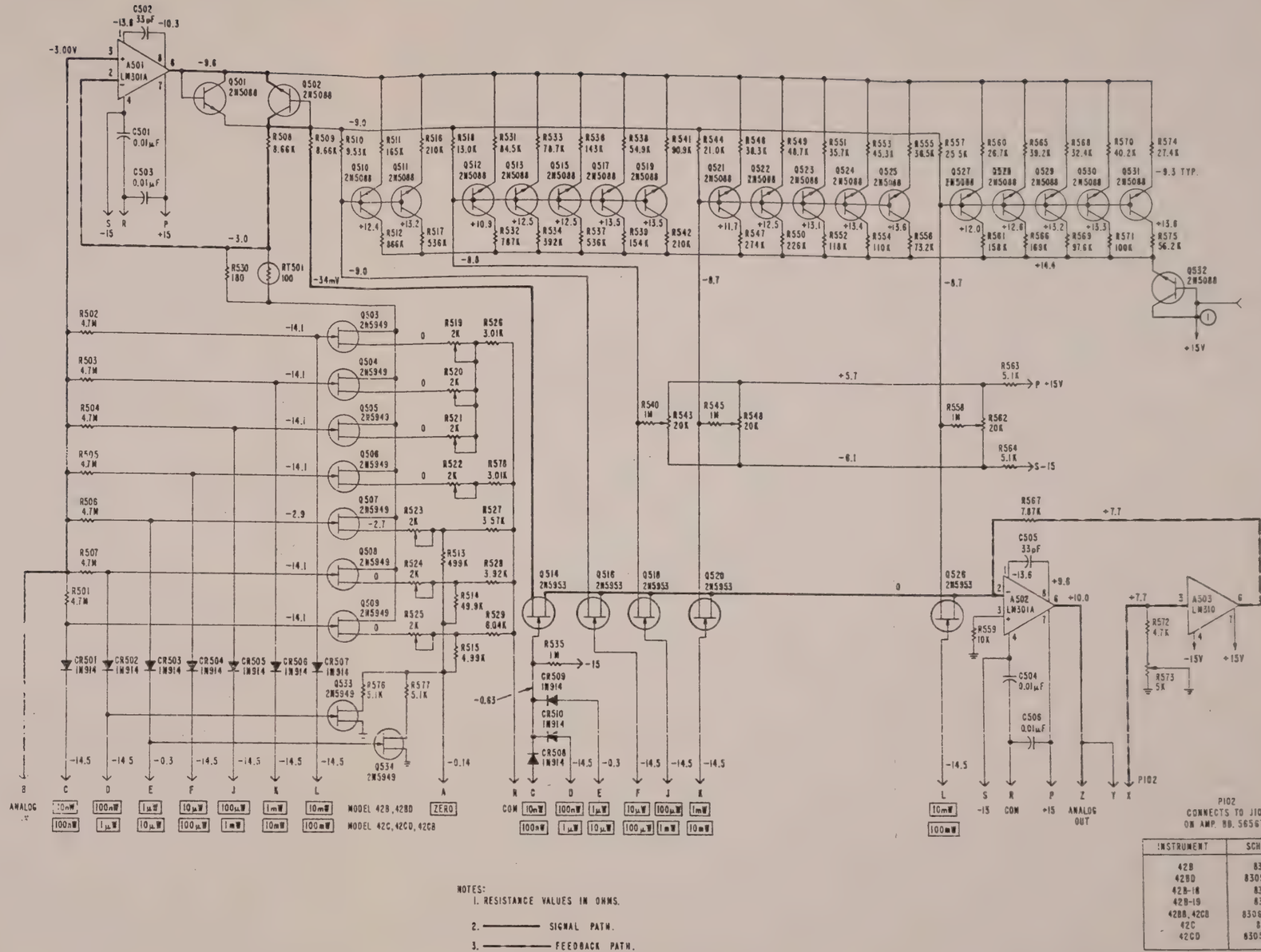


Figure 6-2. Master Board Parts-Location and Schematic Diagram



Parts-Location Diagram (C830609C)

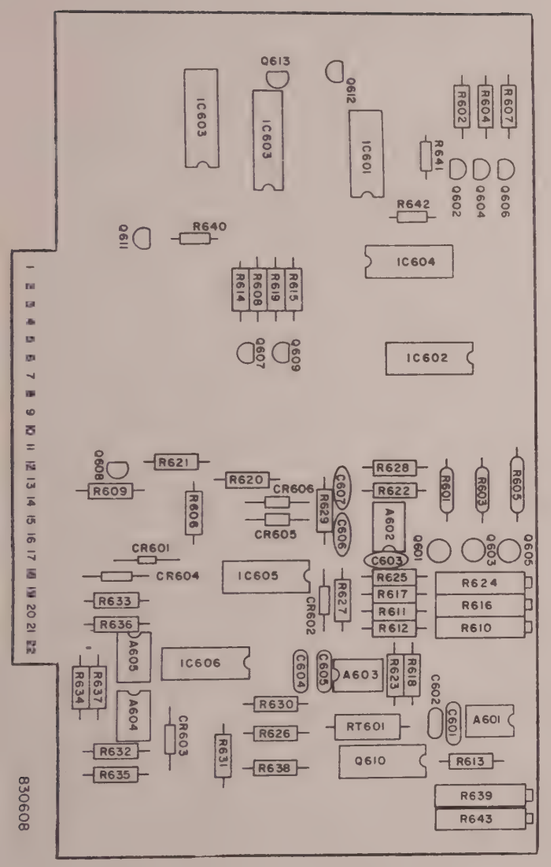


830592M
Sh 2 of 3

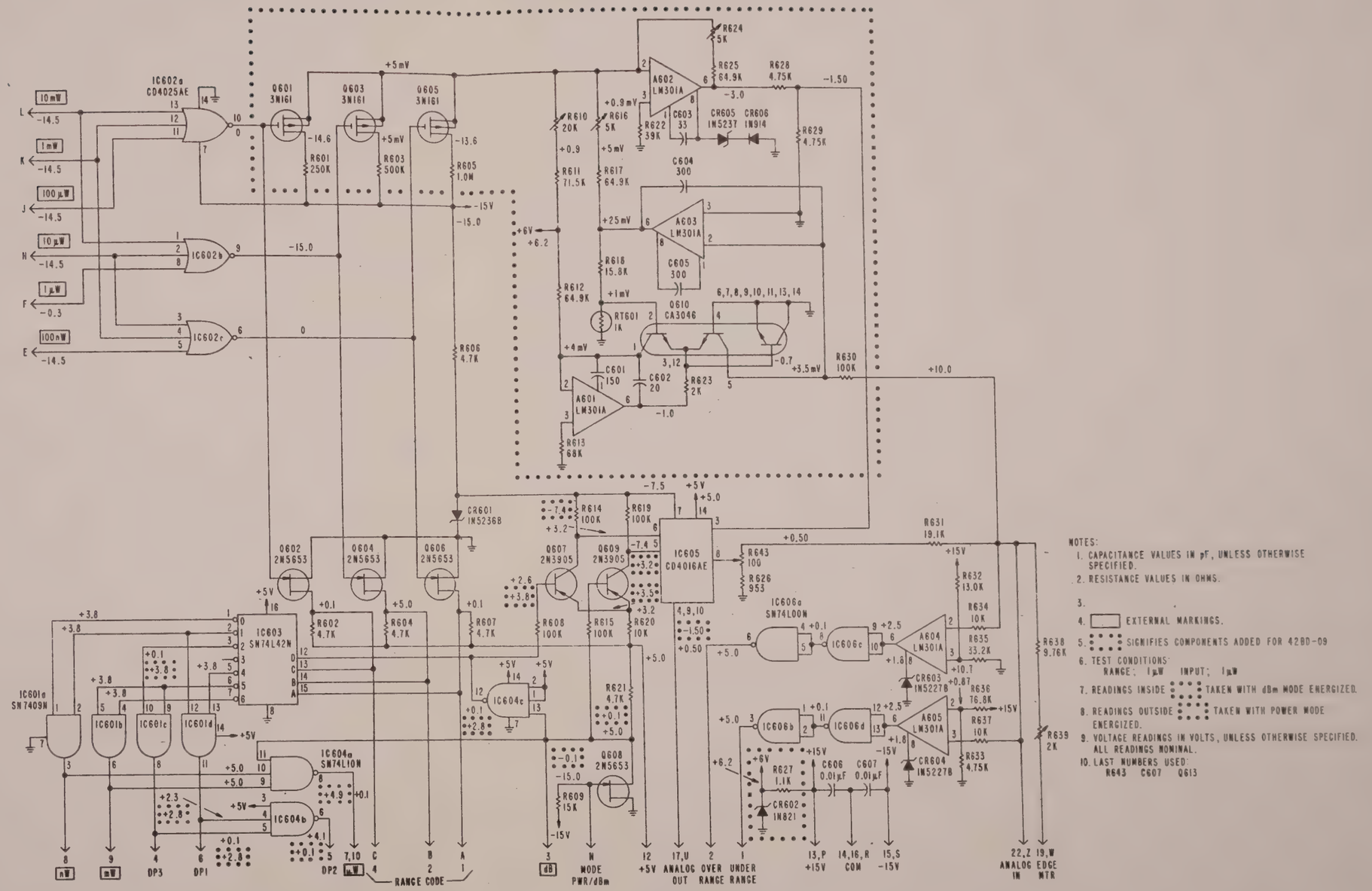
NOTES:
1. RESISTANCE VALUES IN OHMS.
2. ——— SIGNAL PATH.
3. — — — FEEDBACK PATH.
4. ▭ EXTERNAL MARKINGS
5. ◯ TEST POINT.
6. LAST NUMBER USED:
   R578 C506 Q534 CR510 A503
7. TEST CONDITIONS:
   RANGE: 1 μV, SIGNAL: 1 μV — 428,428D
   RANGE: 10 μV, SIGNAL: 10 μV — 42C,42CD
   ALL READINGS IN VOLTS, UNLESS OTHERWISE SPECIFIED. ALL READINGS NOMINAL.

INSTRUMENT	SCHEMATIC
428	830636
428D	830592 SHT.1
428-18	830640
428-19	830641
428B,42CB	830658 SHT.1
42C	830636
42CD	830592 SHT.1

Figure 6-3. Shaping Amplifier Parts-Location and Schematic Diagram



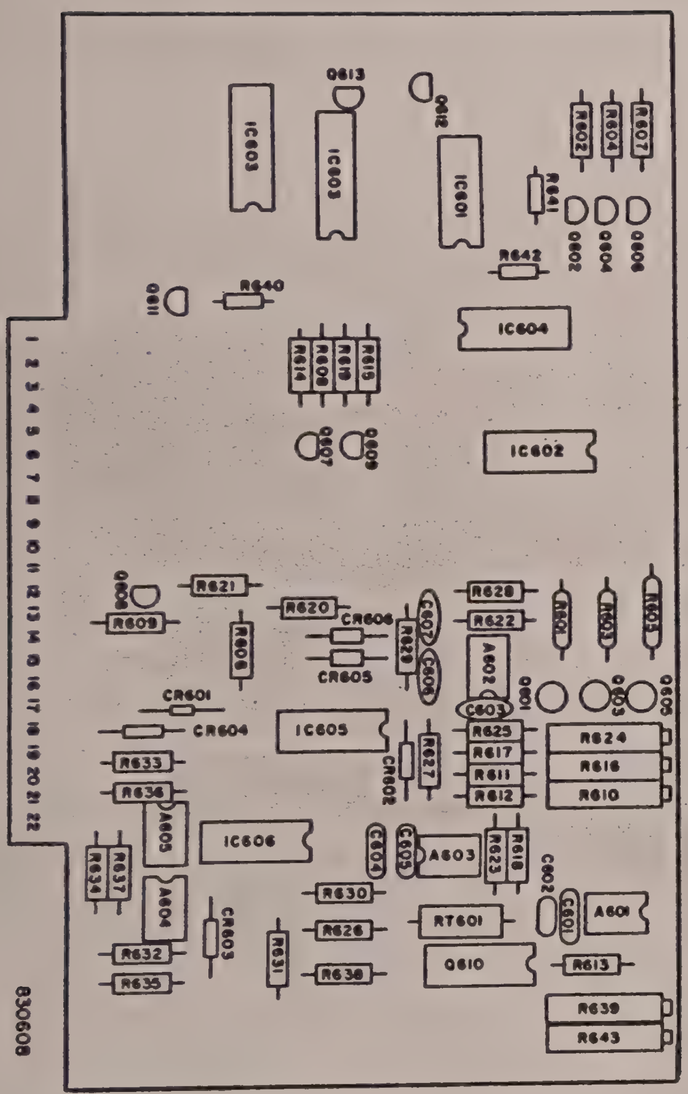
Parts-Location Diagram (C830608C)



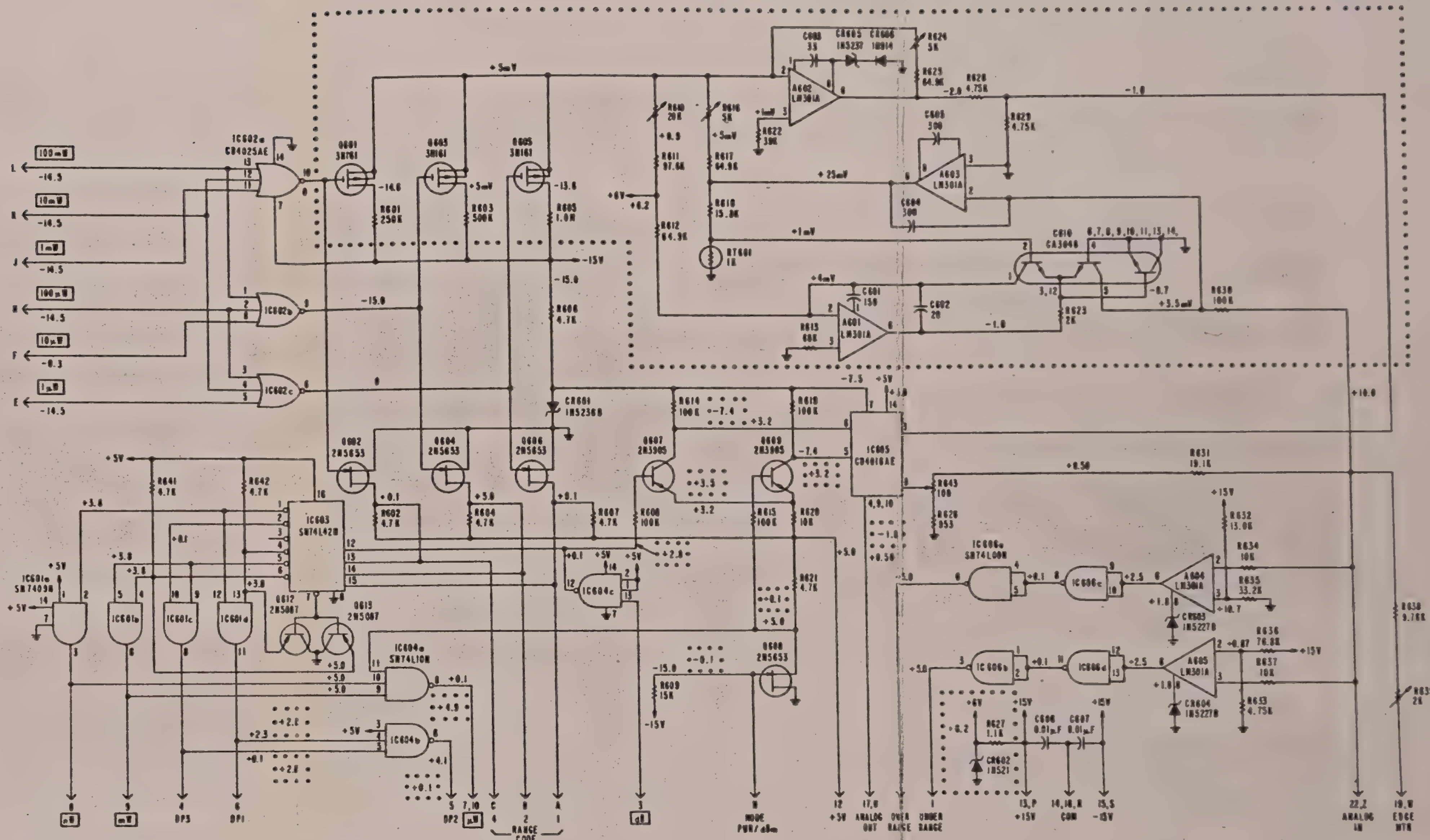
NOTES:
1. CAPACITANCE VALUES IN pF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3.
4. EXTERNAL MARKINGS.
5. SIGNIFIES COMPONENTS ADDED FOR 42BD-09
6. TEST CONDITIONS: RANGE; 1µW INPUT; 1µW
7. READINGS INSIDE TAKEN WITH dBm MODE ENERGIZED.
8. READINGS OUTSIDE TAKEN WITH POWER MODE ENERGIZED.
9. VOLTAGE READINGS IN VOLTS, UNLESS OTHERWISE SPECIFIED. ALL READINGS NOMINAL.
10. LAST NUMBERS USED: R643 C607 Q613

830592E
Sh 3 of 3

Figure 6-4. 42BD Digital-Control Board Parts-Location and Schematic Diagram



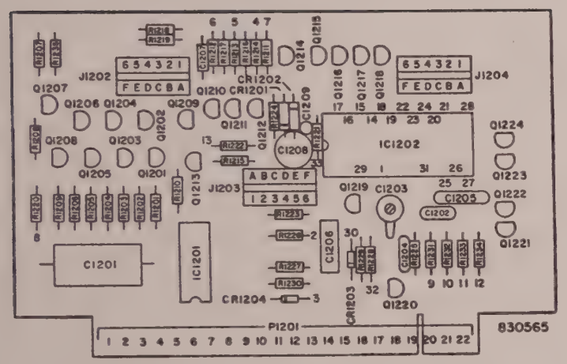
Parts-Location Diagram (C830608C)



NOTES:
1. CAPACITANCE VALUES IN pF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS.
3.
4. [ ] EXTERNAL MARKINGS.
5. [dotted box] SIGNIFIES COMPONENTS ADDED FOR 42CD-09
6. TEST CONDITIONS:
   RANGE: 10μW INPUT: 10μW
7. READINGS INSIDE [dotted box] TAKEN WITH dBm MODE ENERGIZED.
8. READINGS OUTSIDE [dotted box] TAKEN WITH POWER MODE ENERGIZED.
9. VOLTAGE READINGS IN VOLTS, UNLESS OTHERWISE SPECIFIED. ALL READINGS NOMINAL.
10. LAST NUMBERS USED:
    R643 C607 Q613

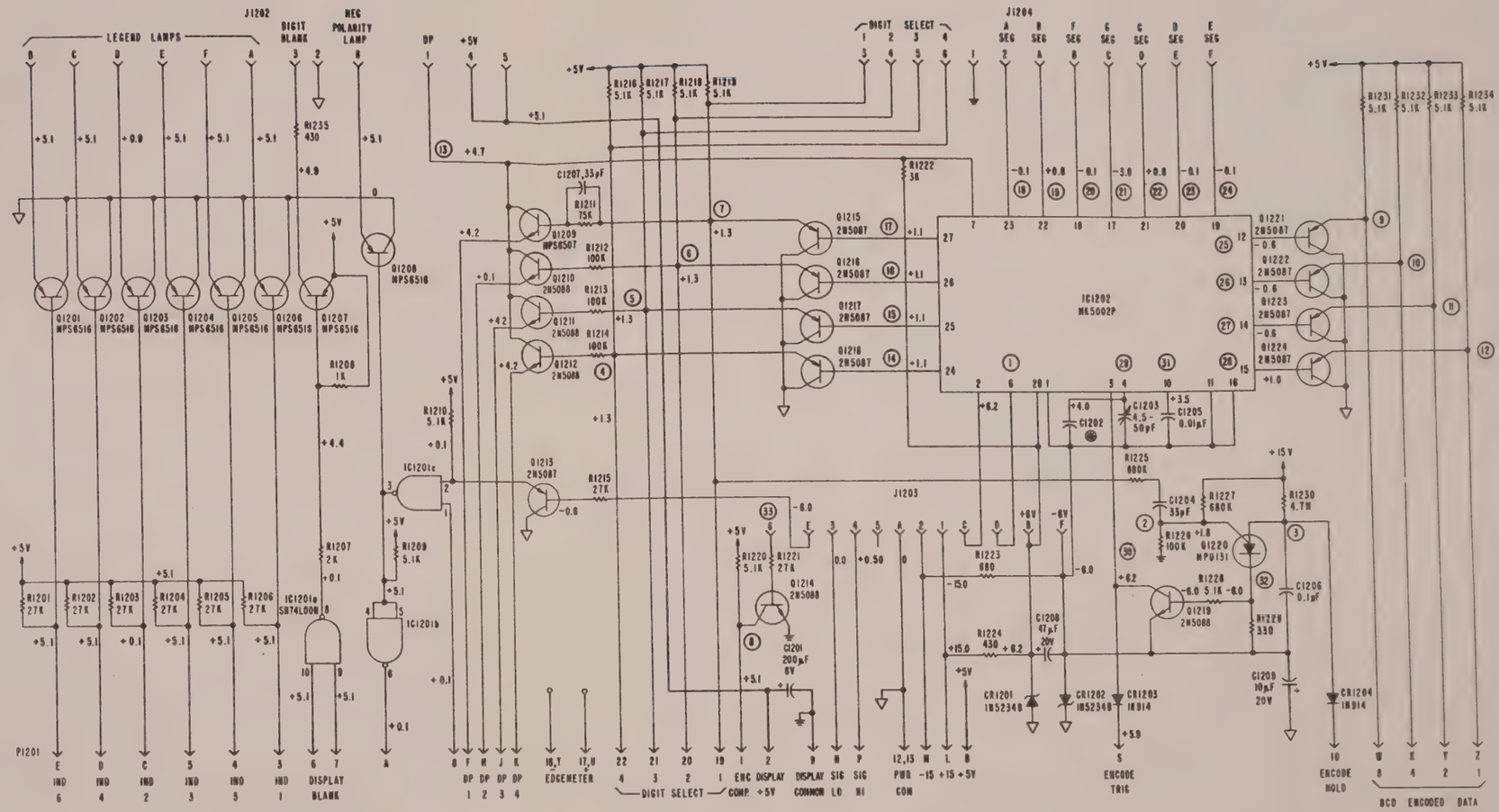
830768B

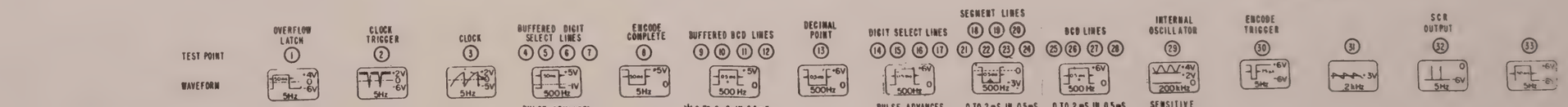
Figure 6-5. 42CD Digital-Control Board Parts-Location and Schematic Diagram



NOTE:
NUMBERS WITHOUT A LETTER PREFIX
DENOTE A SCHEMATIC TEST POINT.

Parts-Location Diagram (B830565F)





NOTES:
1. RESISTANCE VALUES IN OHMS AND 1/4 WATT, UNLESS OTHERWISE SPECIFIED.
2. ⊛ FACTORY SELECTED.
3. TEST CONDITIONS:
   ALL MEASUREMENTS MADE WITH +0.5V INPUT. ADJ. R1405 TO +1000 COUNTS.
   ALL VALUES NOMINAL.
4. LAST NUMBERS USED:
   R1235 C1209 Q1224
5. ▽ COMMON

830546H
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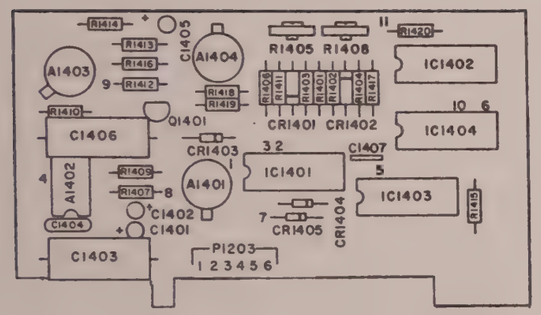
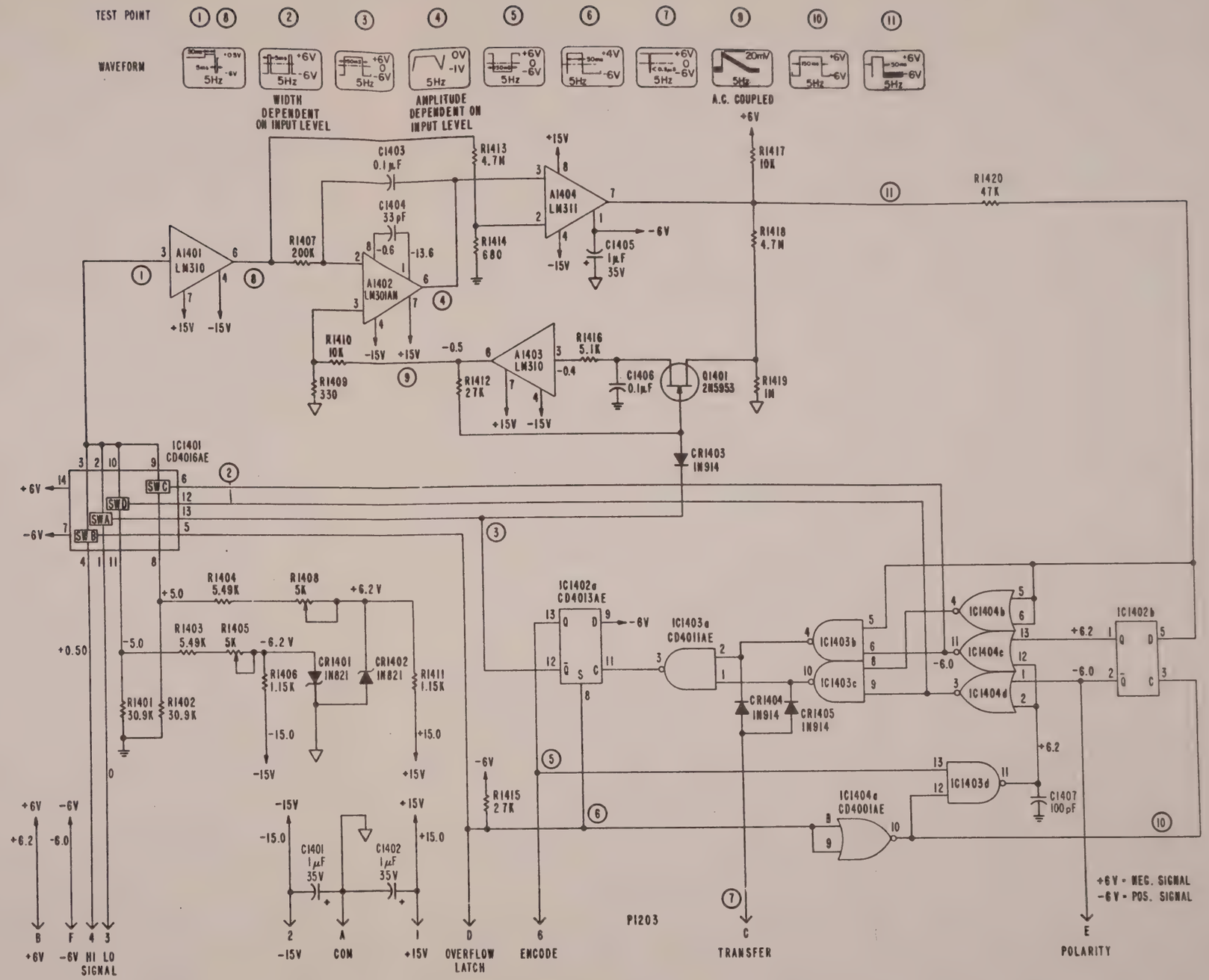
Figure 6-6. Counter Board Parts-Location and Schematic Diagram



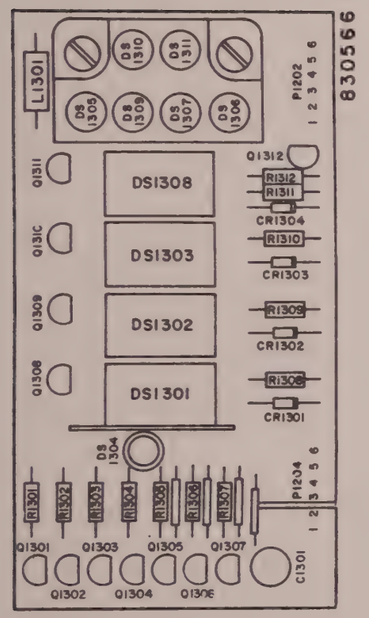
NOTE:
NUMBERS WITHOUT A LETTER PREFIX DENOTE A SCHEMATIC TEST POINT.

Parts-Location Diagram (B830564F)

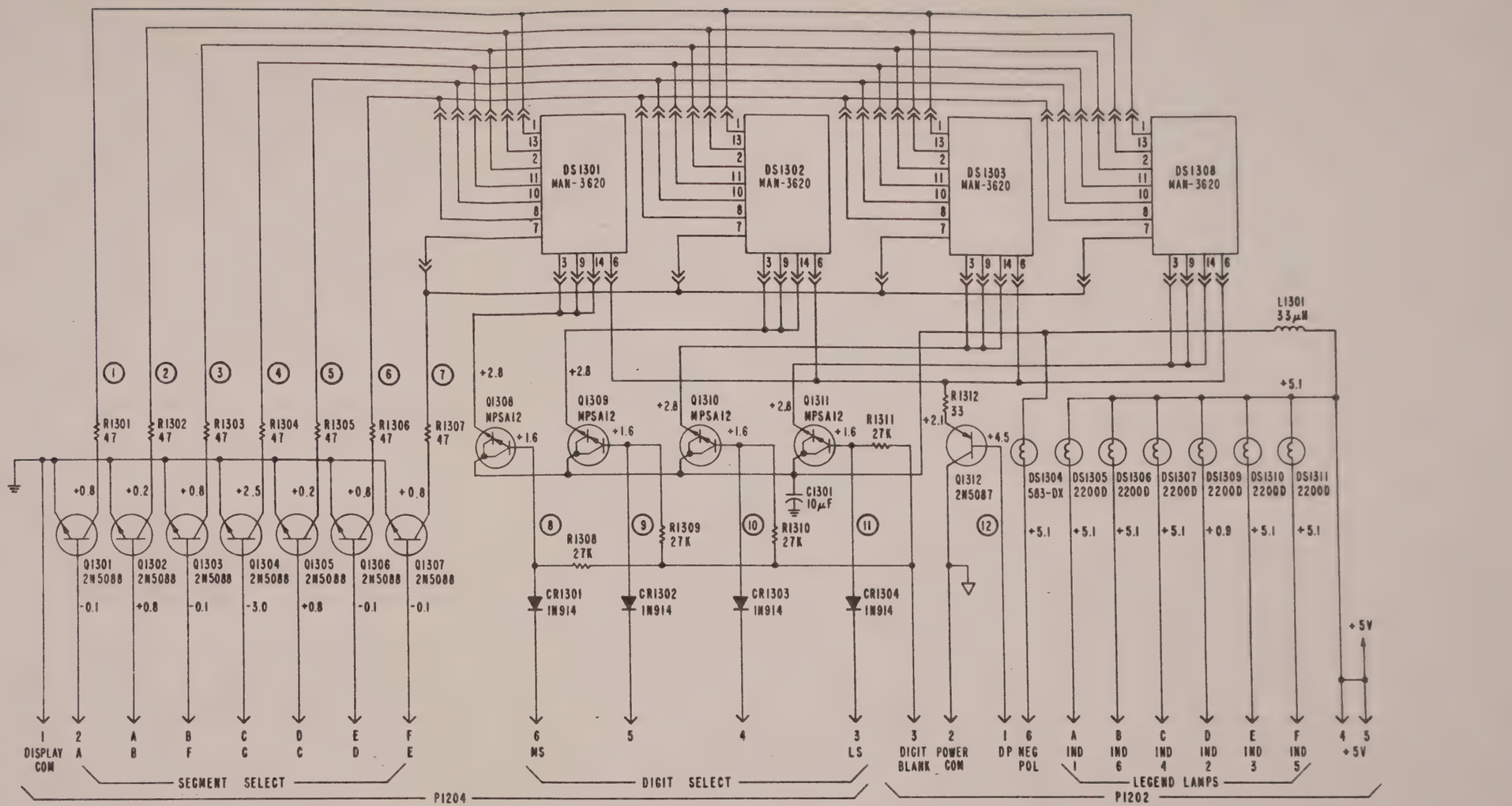


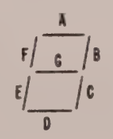
NOTES:
1. RESISTANCE VALUES IN OHMS.
2.
3. TEST CONDITIONS:
ALL MEASUREMENTS MADE WITH +0.5 Vdc INPUT (1000 COUNTS).
ALL VALUES NOMINAL.
4. LAST NUMBERS USED:
R1420 C1407
5. ⏚ COMMON

Figure 6-7. A-D Converter Board Parts-Location and Schematic Diagram



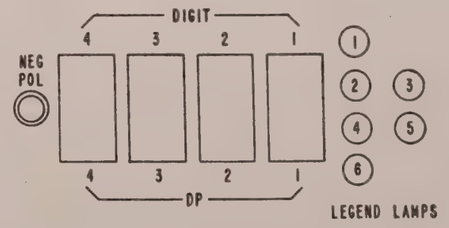
Parts-Location Diagram (B830566D)

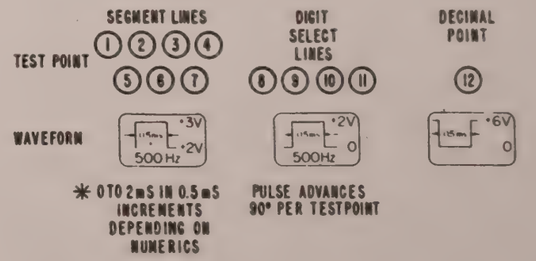




NOTES:

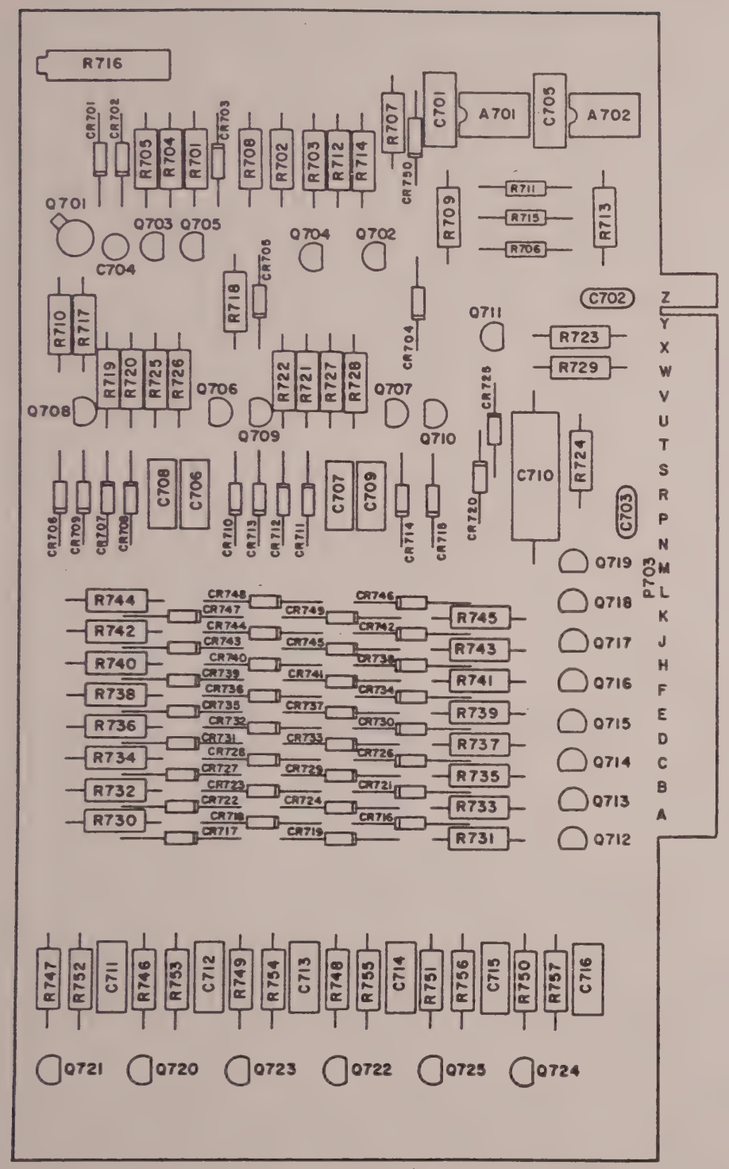
1. RESISTANCE VALUES IN OHMS AND 1/4WATT, UNLESS OTHERWISE SPECIFIED.
2. LAST NUMBERS USED:
   R1312, Q1312, DS1311, CR1304
3. TEST CONDITIONS:
   ALL MEASUREMENTS WITH 0.5Vdc INPUT (1000 COUNTS).
   ALL VALUES NOMINAL



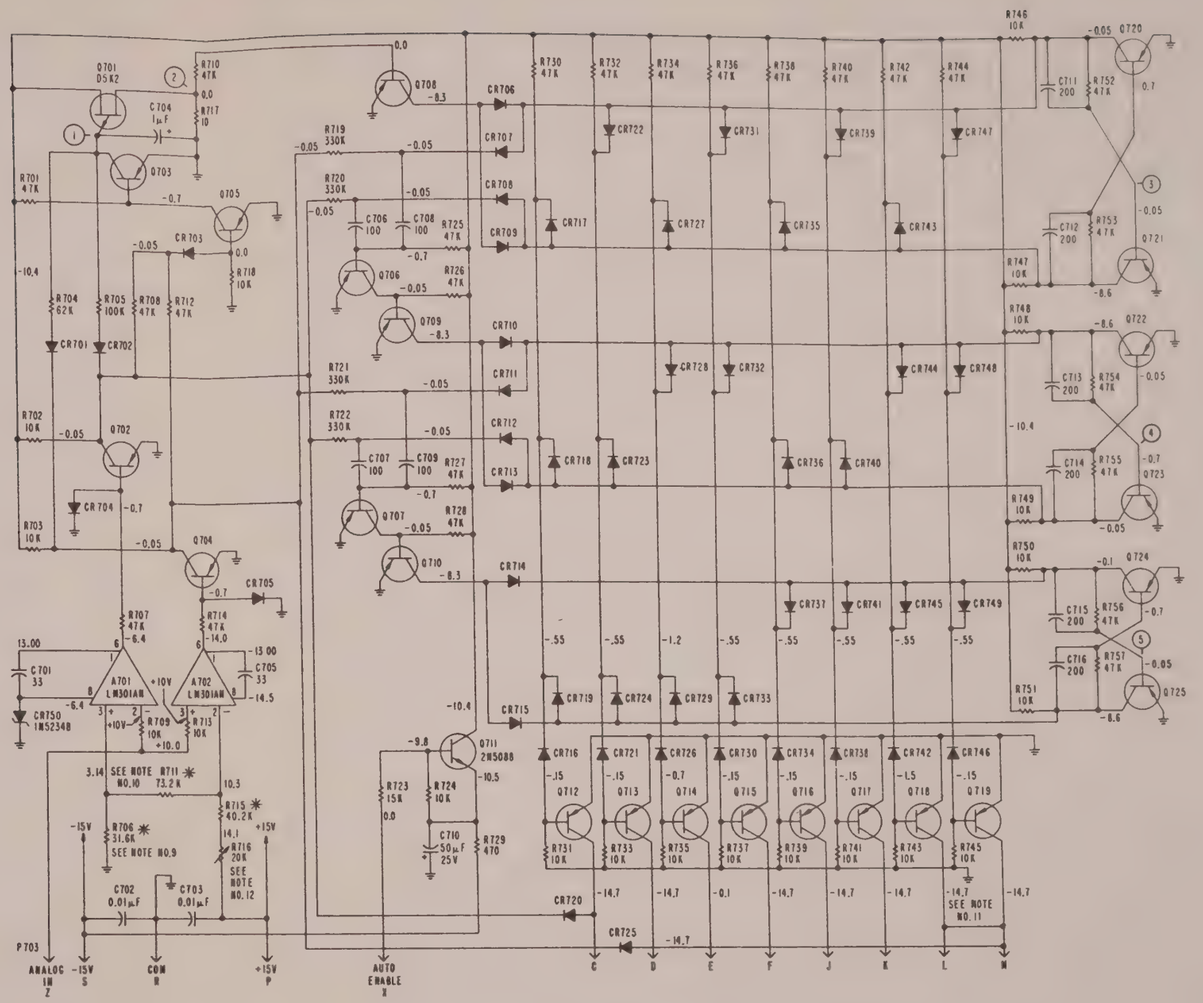


830546J
Sh 2of 3

Figure 6-8. Display Board Parts-Location and Schematic Diagram



Parts-Location Diagram (C831059B)



NOTES:

1. CAPACITANCE VALUES IN pF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS AND 1/2 WATT, UNLESS OTHERWISE SPECIFIED.
3. ✳ PRECISION RESISTORS.
4. ALL TRANSISTORS TO BE TYPE MPS6516, UNLESS OTHERWISE SPECIFIED.
5. ALL DIODES TO BE TYPE IN914, UNLESS OTHERWISE SPECIFIED.
6. WAVESHAPES OCCUR DURING RANGE CHANGE ONLY.
7. ALL VOLTAGE READINGS NOMINAL VOLTS.
8. LAST NUMBERS USED:
   R757 C716 Q725 CR750
9. ON MODELS 42BD-01 AND 42CD-01 THIS VALUE IS 9.53 K.
10. ON MODELS 42BD-01 AND 42CD-01 THIS VALUE IS 95.3K.
11. THIS CONNECTION FOR 42BD-01 AND 42CD-01.
12. ON MODELS 42BD-01 AND 42CD-01 THIS VALUE IS 50K.
13. TEST CONDITIONS:

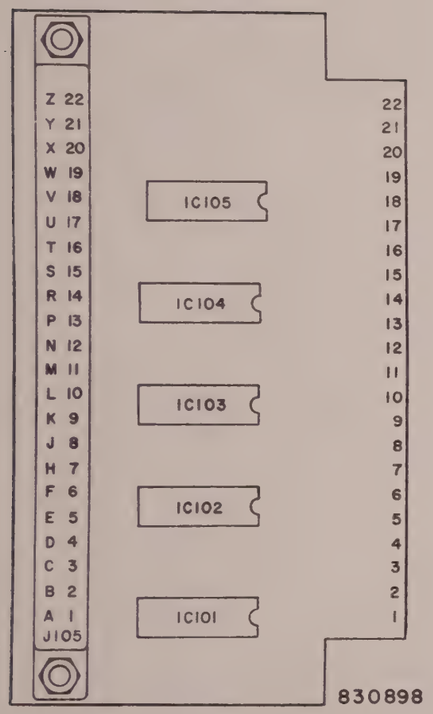
	92BD	42BD	42CD
RANGE:	10mV	1μW	10μW
INPUT:	10mV	1μW	10μW

FULL SCALE MARKINGS FOR P703

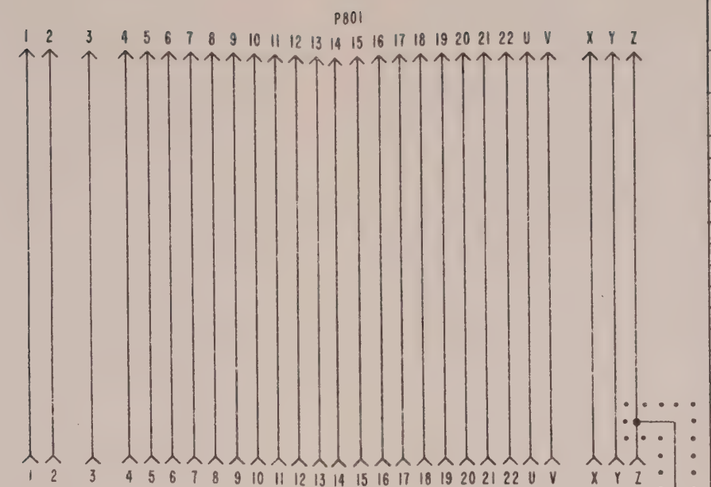
P703	92BD	42BD	42CD
C	1mV	10nW	100nW
D	3mV	100nW	1μW
E	10mV	1μW	10μW
F	30mV	10μW	100μW
J	100 mV	100μW	1mW
K	300mV	1mW	10mW
L	1000 mV	10mW	100mW
M	3000 mV	—	—

830483F

Figure 6-9. AutoRange Board Parts-Location and Schematic Diagram

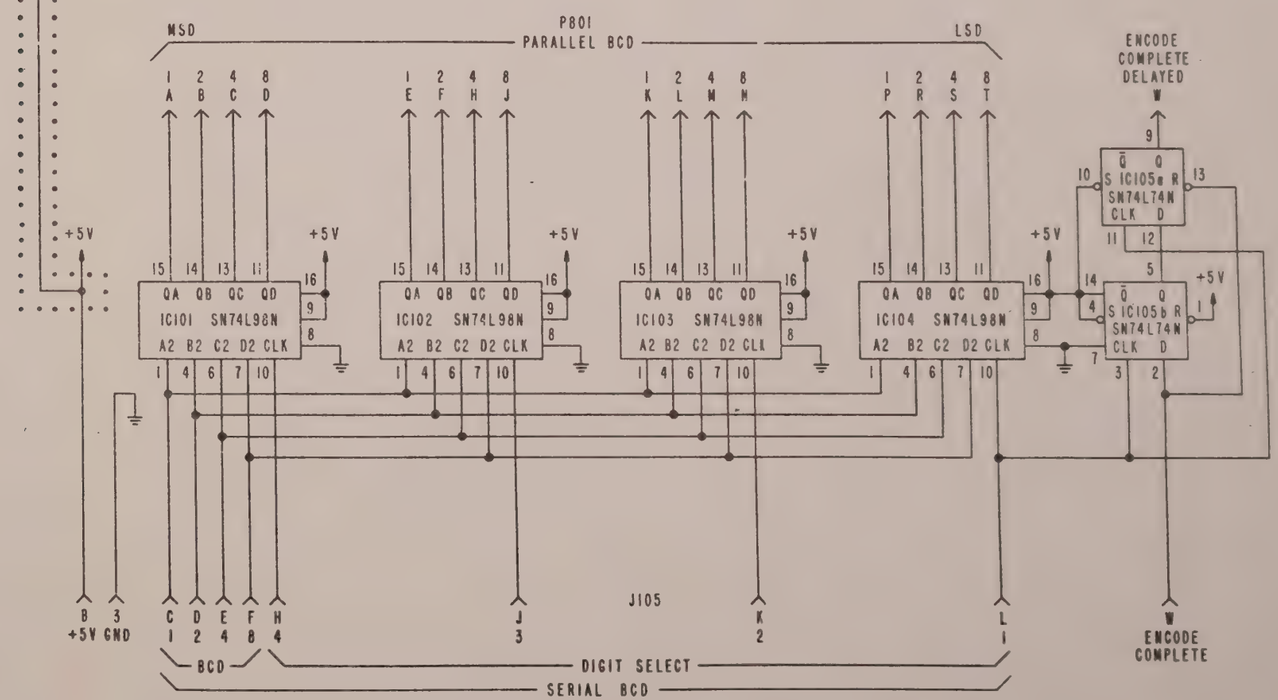


Parts-Location Diagram (B830898A)



PIN ASSIGNMENTS

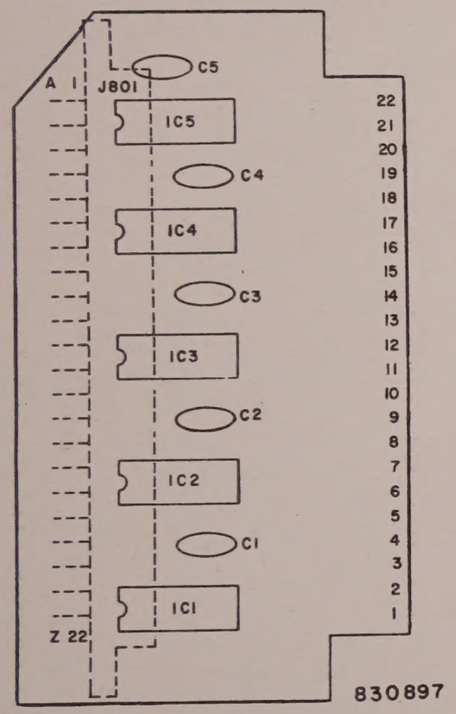
P801						P801			
	42BD	42CD	92BD	72BD		42BD	42CD	92BD	72BD
1				HI TERM BIAS ±	A	1			
2	- dBm			LO TERM BIAS ±	B	2	MSD		
3	LOGIC GROUND				C	4			
4	ANALOG OUTPUT				D	8			
5	COMMON				E	1			
6	AUTO ENABLE				F	2			
7	MANUAL DISABLE				H	4		BCD	
8	dBm ENABLE				J	8		ENCODED	
9			3000 mV		K	1		DATA	
10	10 mW	100 mW	1000 mV	2000 pF	L	2			
11	1 mW	10 mW	300 mV		M	4			
12	100 µW	1 mW	100 mV	200 pF	N	8			
13	10 µW	100 µW	30 mV		P	1			
14	1 µW	10 µW	10 mV	20 pF	R	2	LSD		
15	100 nW	1 nW	3 mV		S	4			
16	10 nW	100 nW	1 mV	2 pF	T	8			
17	4			2	U				
18	2	RANGE CODE		1	V	TRIGGER			
19	1				W	COMPLETE	ENCODE		
20	UNDERRANGE "NOT"				X	HOLD			
21	OVERRANGE "NOT"				Y				
22	PWR MODE		mV MODE	POLARITY	Z				



NOTE:
1. LOGIC LEVEL; TTL/DTL COMPATIBLE.
2. • • • • • • USED ON 92-9A ONLY.

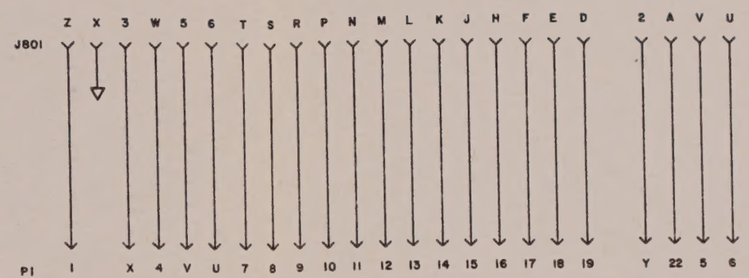
830650C

Figure 6-10. Serial-Parallel BCD Converter Parts-Location and Schematic Diagram



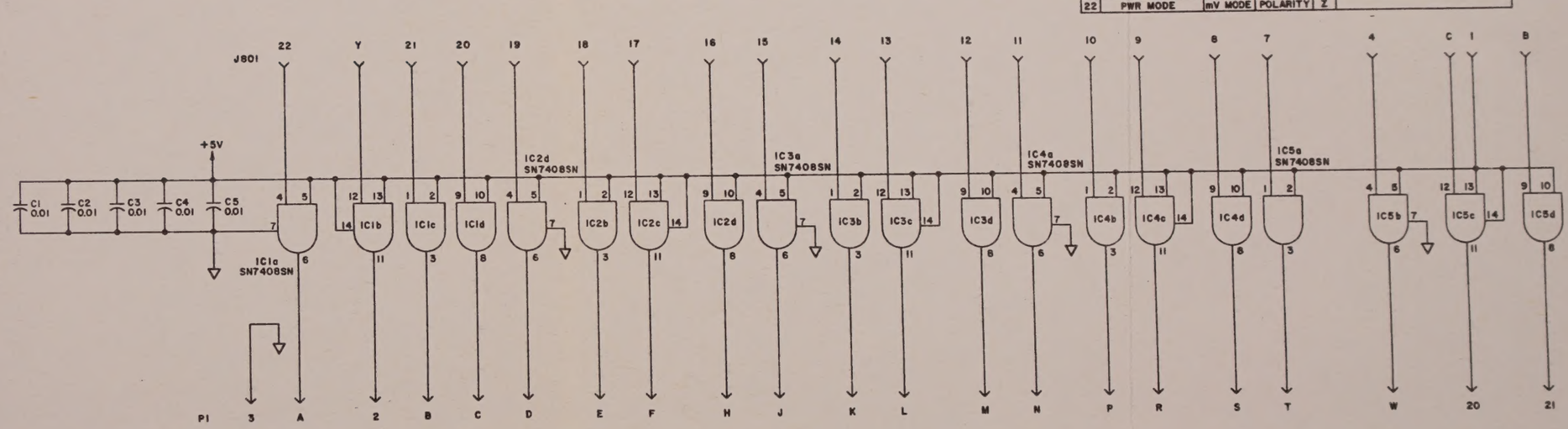
Parts-Location Diagram (B830897A)

J 801 CONNECTS TO
P 801 ON
SERIAL / PARALLEL BCD
CONVERTER P.C. BOARD
NO. 565925
SCHEMATIC 830650



PIN ASSIGNMENTS

P1									
	42BD	42CD	92BD	72BD		42BD	42CD	92BD	72BD
1				HI TERM BIAS ±	A	1			
2	-dBm			LO TERM BIAS ±	B	2	MSD		
3	LOGIC GROUND				C	4			
4	ANALOG OUTPUT				D	8			
5	COMMON				E	1			
6	AUTO ENABLE				F	2			
7	MANUAL DISABLE				H	4	BCD		
8	dBm ENABLE				J	8	ENCODED		
9			3000mV		K	1	DATA		
10	10mW	100mW	1000mV	2000pF	L	2			
11	1mW	10mW	300mV		M	4			
12	100µW	1mW	100mV	200pF	N	8			
13	10µW	100µW	30mV		P	1			
14	1µW	10µW	10mW	20pF	R	2	LSD		
15	100nW	1nW	3mV		S	4			
16	10nW	100nW	1mV	2pF	T	8			
17	4			2	U				
18	2	RANGE CODE		1	V	TRIGGER			
19	1				W	COMPLETE	ENCODE		
20	UNDERRANGE "NOT"				X	HOLD			
21	OVERRANGE "NOT"				Y				
22	PWR MODE		mV MODE	POLARITY	Z				



NOTES:
1. CAPACITANCE VALUES IN µF.
2. ▽ COMMON
3. LAST NUMBERS USED:
   C5 IC5

830900A

Figure 6-11. Serial-Parallel Output Buffer Parts-Location and Schematic Diagram

WARRANTY

Boonton Electronics Corporation warrants its products to the original purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to active devices that have given normal service, to sealed assemblies which have been opened or to any item which has been repaired or altered without our authorization.

We will repair, or at our option, replace any of our products which are found to be defective under the terms of this warranty.

There will be no charge for parts, labor, or forward and return normal ground transportation during the first three months of this warranty.*

There will be no charge for parts, labor, or return normal ground transportation during the fourth through twelfth month of this warranty.*

Except for such repair or replacement, we will not be liable for any incidental damages or for any consequential damages, as those terms are defined in Section 2-715 of the Uniform Commercial Code, in connection with products covered by this warranty.

*For *overseas shipments,* there will be no charge for Air Freight during these specified time periods.

BOONTON

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TELEPHONE: (201) 584-1077 ■ TLX: 710-986-8215 BOONTRONICS

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